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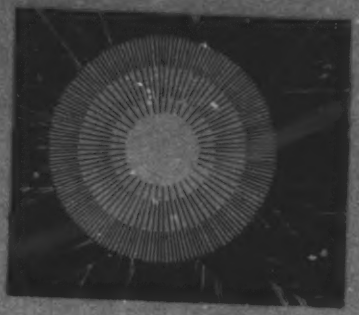

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DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY

SOLAR ENERGY PILOT STUDY

FINAL REPORT

OCTOBER 1978

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NATO COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY

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Prepared for the

U.S. Department of Energy
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ABSTRACT

The CCMS Solar Energy Pilot Study was established in 1973 with the objective of encouraging the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, industrial, agricultural, and public buildings. The scope of the pilot study has been the exchange of information on (1) national solar heating and cooling programs, (2) solar heating and cooling experiments, with emphasis on system performance data, and (3) specialized regional applications of solar heating and cooling. In this Final Report, the various elements of this multilateral cooperative program are described briefly in the Executive Summary and discussed in further detail in other sections of the report. Significant accomplishments, an assessment by the Participants of the effectiveness of this project, and recommendations of the pilot study for follow-up activities at both the national and international levels are also included.

PREFACE

This report is the Final Report of the CCMS Solar Energy Pilot Study. It summarizes the activities and accomplishments of the project during its five year lifetime (1973-1978), a period which coincided with the beginning of significant solar energy programs throughout the world. The Pilot Study provided a unique opportunity for those responsible for the planning, direction and implementation of solar heating and cooling programs and projects in over twenty countries to exchange plans, information, ideas and data during the formative stages of these national programs.

The general objectives and broad scope of a solar energy pilot study were conceptualized by Mr. Frank Hodsoll (U. S. Department of State) and Mr. Raymond Fields (U. S. National Science Foundation) in the Spring of 1973. The establishment of a Solar Energy Pilot Study was recommended by the CCMS at its October 1973 Plenary Meeting and formally approved by the North Atlantic Council in November 1973. The United States accepted the responsibilities of pilot country, and Denmark and France offered to assist as co-pilot countries.

The success of cooperative programs, especially on the scale of the CCMS Pilot Study, depends to a significant degree on the dedicated efforts of certain individuals and the support of their organizations. The first Director of the Solar Energy Pilot Study, Mr. Raymond Fields, was responsible for initiating the first and very important Pilot Study Meeting. Mr. Tex Harris and Ms. Edwina Campbell drafted the Memorandum of Understanding and sought broad participation in it by NATO and non-NATO countries alike. To a large degree, the success of this Pilot Study was due to their skills and efforts during the first years. Prof. Vagn Korsgaard of Denmark, Dr. Helmut Klein of the Federal Republic of Germany, Dr. Michel Rodot of France, and Prof. Frederick Morse of the United States played major roles in the formation and initiation of the working elements of the pilot study.

During the following years, many others have made significant contributions to the pilot study. They include Ms. Ann Korky and Mr. Tim Savage (U. S. Department of State), Mr. Paul Von Ward and Ms. Lynn Schoolfield (U. S. Environmental Protection Agency), Mr. Torben Esbensen (Technical University of Denmark), Mr. Joseph Perry (U. S. Los Alamos Scientific Laboratory), Mr. Cameron Sanders and Mr. James Sampas (NATO-CCMS Office) and Dr. Jack Vanderryn (U. S. Department of Energy).

During the five-year pilot study, the responsibilities of the lead country, the United States, shifted from the National Science Foundation, to the Energy Research and Development Administration, and finally to the Department of Energy. Throughout that period, the CCMS Projects Office at the University of Maryland provided administrative support of the highest quality, through the efforts of Ms. Sheila Blum and Dr. Redfield Allen, and Dr. Ingrid Rose. That office organized and implemented the information exchange system, planned and supported the annual

meetings, and coordinated the many activities that make a successful cooperative program.

The support of these people, their organizations and mine, the Office of Conservation and Solar Applications, Department of Energy, is gratefully acknowledged.

Frederick H. Morse
Director
CCMS Solar Energy Pilot Study

TABLE OF CONTENTS

	Page
PREFACE	iii
EXECUTIVE SUMMARY	
Introduction	1
CCMS - Background	1
Solar Energy Pilot Study - Background	2
Structure	3
Elements of the Pilot Study	4
Accomplishments	7
Resolutions and Recommendations	8
Concluding Remarks	12
REVIEW OF NATIONAL PROGRAMS	13
CCMS SYSTEM PERFORMANCE REPORTING FORMAT	22
CCMS/ISES SOLAR ENERGY CONFERENCE	29
ZERO ENERGY HOUSE GROUP	37
MEDITERRANEAN APPLICATIONS GROUP	46
PARTICIPANTS' ASSESSMENT OF THE PILOT STUDY	55
APPENDIX	
A - Memorandum of Understanding	61
B - Participating Countries and Contact Persons	63
C - Pilot Study Meetings	67
D - Text of the CCMS Reporting Format and Format Summary Outline	76
E - Reports Exchanged by Participating Countries	86
F - Pilot Study Publications	94

EXECUTIVE SUMMARY

INTRODUCTION

Interest in direct utilization of the sun's radiation is not new. The Association for Applied Solar Energy - now the International Solar Energy Society - was organized in 1954 to advance the utilization of solar energy. In the 1950's and 60's a number of international symposia were convened, including the World Symposium on Applied Solar Energy (Phoenix, Arizona - 1955) and the United Nations Conference on New Sources of Energy (Rome - 1961). During those decades a relatively small number of applied reserach projects were conducted at research centers around the world. However, with the exception of solar water heating in several countries, widespread availability of cheap fossil fuels impeded the technical development of solar energy.

Clearly, the energy situation has shifted dramatically during the 1970's. Traditional energy sources are being rapidly depleted and becoming increasingly expensive. The oil crisis of 1973-74 demonstrated the need to foster a greater degree of energy independence. These factors have served to focus attention on alternative sources of energy and specifically on solar energy as a viable renewable energy source. Consequently, countries in all parts of the world have expanded their national research and development programs to include the investigation of solar applications.

Buildings are prime users of energy in industrialized nations. For example, approximately 25% of the energy consumed in the United States goes for providing the heating, cooling, and domestic hot water supply of buildings; in the Federal Republic of Germany, this figure is even higher - 40%. Thus, any significant replacement of fossil fuels by solar energy in the buildings sector will have an important impact on the energy situation. Fortunately, one of the most promising areas for near-term utilization of solar energy appears to be in low-temperature applications for buildings. Important contributions are also possible in low and moderate temperature agricultural and industrial process heat applications. Technology is making more advanced and reliable solar hardware available, and while the high cost of solar systems is a serious problem, rising fossil fuel prices are beginning to make solar space and domestic water heating cost-effective in many locations. International cooperation plays a major role in promoting and advancing the utilization of solar energy by sharing knowledge and experience and by forming a broad-based attack on some of the remaining impediments to its wide-scale implementation.

CCMS – BACKGROUND

The NATO Committee on the Challenges of Modern Society was established in 1969 to respond to the complex technological and environmental problems facing industrialized nations. CCMS has become an effective mechanism for identifying these

challenges and establishing cooperative programs which respond to these issues by the sharing of efforts and resources.

The CCMS pioneered the pilot study method whereby a lead country, rather than an International Secretariat, conduts a project in an area of common interest. CCMS also maintains a policy of open publication and open membership, since the problems it deals with are of global concern.

Sufficient supplies of energy are essential to the maintenance of the quality of life in industrialized societies and for continued world-wide progress and growth. CCMS was the first international organization to deal with the imperatives of alternative energy development and energy conservation.

SOLAR ENERGY PILOT STUDY – BACKGROUND

At the April 1973 CCMS Spring Plenary, Mr. Russell Train, then Administrator of the Environmental Protection Agency and U. S. representative to the CCMS, stressed the urgent need to match energy supply to demand, to deal with the diminishing supply of fossil fuels, and to develop less environmentally-damaging sources of energy. His proposal that the CCMS apply its successful approach to the vital area of energy by undertaking pilot studies in the areas of solar and geothermal energy received strong support from the delegations and was followed by a related proposal for creation of an energy conservation pilot study in the Fall of 1973.

The establishment of a Solar Energy Pilot Study was recommended by the CCMS at its October 1973 Plenary Meeting and formally approved by the North Atlantic Council in November 1973.

The overall objective of the CCMS Solar Energy Pilot Study was to encourage the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, industrial, agricultural and public buildings. The scope of the pilot study was defined as exchange of information on solar heating, cooling and domestic hot water systems in buildings with special emphasis on national programs and system performance.

The inaugural meeting of the pilot study took place in October 1974 at Odeillo, France. During the ensuring four years a number of cooperative activities were undertaken to fulfill the objective. The Executive Summary of this Final Report provides a brief description of these activities, as well as the major accomplishments of the pilot study. Detailed information on each element of the project is contained in the body of this report. Looking ahead, as the formal phase of the pilot study concludes and a two-year CCMS follow-up period is initiated, recommendations for future action on both the national and international levels are also presented.

STRUCTURE

Memorandum of Understanding

The guidelines for this multilateral program are contained in a Memorandum of Understanding (See Appendix A). The Memorandum of Understanding (MOU) calls for cooperative exchange of information on (1) national solar heating and cooling programs and (2) solar system and sub-system experiments. The signatories to the MOU agree to:

- Develop a format for reporting performance of solar heating and cooling systems
- Exchange system performance reports prepared in accordance with that format
- Exchange additional publically-available solar heating and cooling reports
- Participate in meetings for the review of national solar heating and cooling programs and system projects.

Lead Countries

As pilot country, the United States was reponsible for directing and carrying out this study. The lead agency for the United States has been the U. S. Department of Energy (formerly Energy Research and Development Administration). Mr. Raymond Fields, the first Pilot Study Director, was succeeded by Dr. Frederick Morse. The University of Maryland's Department of Mechanical Engineering provided program support to the Department of Energy. The co-pilot countries, Denmark and France, played major roles in the leadership of this pilot study.

Participants

Inasmuch as it is the policy for CCMS projects to be open to any interested country, both NATO and non-NATO nations participated in the Solar Energy Pilot Study. Fifteen countries have become signatories to the Memorandum of Understanding:

Australia
Belgium
Canada
Denmark
France
Federal Republic of Germany
Greece
Israel
Italy
Jamaica
The Netherlands
New Zealand
Spain
United Kingdom
United States

Eight additional countries, plus the European Commission, participated as unofficial members. Each participating country appointed a contact person as primary representative through whom information was exchanged. These contact persons are listed

in Appendix B. Twelve countries also designated a central information contact to assist the primary contact person in internal information dissemination.

ELEMENTS OF THE PILOT STUDY

The framework of the pilot study and its activities were outlined in the Memorandum of Understanding. At the outset of the project, specific activities were developed to carry out the objectives and designated tasks. Furthermore, two sub-projects were established which expanded the exchange to include cooperation in specialized regional solar heating and cooling applications.

The various elements, which are outlined below and discussed in further detail in other sections of this final report, were considered very effective by the Participants, as evidenced by their expressed desire for continued collaboration during the follow-up period. The Pilot Study's recommendations for follow-up activities are contained under "Recommendations and Resolutions."

Review of National Solar Heating and Cooling Programs

In order to provide the pilot study participants with information on the evolving national solar heating and cooling programs in the member countries, status reports were presented by each country at the four pilot study meetings (1974-Odeillo, France; 1975-Palo Alto, California; 1976-Copenhagen, Denmark; and 1978-Dusseldorf, Germany). These presentations enabled the government program officials and technical experts who attended the annual meetings to view their own programs and activities against those of other countries and to note opportunities for expanding or strengthening them. These status reports also allowed participants to note areas appropriate for closer cooperation in order to share experience and expertise and to avoid duplication of efforts. This exchange has influenced the development and expansion of national programs, and the participants have considered this activity to be one of the most beneficial aspects of the pilot study.

CCMS System Performance Reporting Format

In recognition of the vital need to collect and publish system performance data, and the absence of specific guidelines for reporting such data, the Solar Energy Pilot Study undertook to formulate appropriate specifications. Thus, a system reporting format for reporting the measured performance of solar heating and cooling systems was drafted, reviewed, revised, and put into force as the CCMS Reporting Format in 1975. The CCMS Reporting Format provides guidelines on the reporting of the environment, the system project, system description, system thermal performance, economic analysis of the system, and sub-system characteristics and performance. A CCMS Format Summary Outline was also developed to serve as a guide for preparation of a summary or extended abstract of the complete performance report. The texts of both the Reporting Format and the Format Summary Outline are found in Appendix D.

The value of the pilot study's pioneering effort in this area is evidenced by the fact that the CCMS Reporting Format was adopted as a basis for preparing system performance reports within the U. S. Solar Heating and Cooling Program, national

programs of other participating countries, and the IEA Solar Heating and Cooling Program.

Exchange of System Performance Reports

Since the CCMS Solar Energy Pilot Study centered upon information exchange, it was essential that a portion of that exchange be presented in sufficient detail to allow researchers to utilize the results of projects conducted in other countries to supplement their own research programs. Therefore, the preparation and distribution of system performance reports, which have been prepared in accordance with the aforementioned CCMS System Reporting Format, was viewed as a major component of the study. To ensure that meaningful data is provided, the format is intended to be used for reporting the performance of systems which have been operational for at least one complete heating and/or cooling season.

At the time of the format's completion, only a few projects were sufficiently advanced to permit preparation of comprehensive performance reports. That situation steadily improved after 1975, and a total of 30 interim and complete system performance reports have now been distributed through the pilot study. Of that number, sixteen were prepared during 1978 and publically presented at the CCMS-sponsored Conference on the Performance of Solar Heating and Cooling Systems in April, 1978.

CCMS/ISES International Solar Conference

The CCMS/ISES Conference on the Performance of Solar Heating and Cooling Systems* was the first international conference devoted exclusively to the reporting of the measured performance of solar heating and cooling systems in buildings and the first public technical conference sponsored by the CCMS Solar Energy Pilot Study. The April 19-20, 1978 meeting in Dusseldorf, Germany was attended by some 200 engineers, scientists, government officials and businessmen.

The conference gave broad public exposure to the CCMS Reporting Format and was the occasion on which the CCMS Format Summary Outline was utilized extensively in the preparation of the extended abstracts. Sixteen performance reports were given covering residential, non-residential, swimming pool, and industrial process solar applications in ten countries. The meeting was unique in that the papers presented were wholly devoted to design and performance data on solar heating and/or cooling systems which had been operating over all (or most) of a heating and/or cooling season. The difficulty of accumulating such operating data was widely acknowledged and candidly discussed. The acquisition and publication of performance data on a variety of systems operating in different climates was generally felt to be of crucial importance to the success and widespread introduction of solar heating and cooling applications into each country's economy.

The conference proceedings (CCMS Report #85) will enable an even larger audience to benefit from the experimental results of the system projects presented at the meeting.

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* Co-sponsored by the Solar Energy Pilot Study and the German Section of the International Solar Energy Society.

Exchange of Additional Solar Reports

In addition to system performance reports, significant solar heating and cooling reports of general interest were selected and exchanged by the participating countries. Since the inception of the study, approximately seventy such reports (listed in Appendix E) were distributed by eleven countries. Many of these reports contained valuable technical and program information and provided a picture of the broad range of activities underway in member countries.

Zero Energy House Group

From the reports presented on national solar heating and cooling programs at the first pilot study meeting, it became apparent that certain groups of countries, having similar climates and building needs, were stressing similar applications. As a result, the Zero Energy House Group was formed in 1974 by those participating countries experimenting with solar-assisted low-energy dwellings for northern European climatic conditions in order to share experiences and promote close working ties between researchers. A "Zero Energy House" is one in which solar energy is used to meet the reduced energy needs of buildings incorporating various thermal energy conservation features. The seven countries which participated in this working group are Canada, Denmark (Chairman), Federal Republic of Germany, The Netherlands, Sweden, United Kingdom, and United States. This sub-project enabled technical experts from these countries to meet in a small group for the informal and detailed exchange of information on the design aspects and performance measurements of low-energy house projects. The participants agreed that the three group meetings were most valuable and that continued interchange was desirable.

Mediterranean Applications Group

The establishment of the Mediterranean Applications Group, chaired by France, was intended to apply the successful approach of the Zero Energy House Group to cooperation in a different regional application of solar energy. Following expressions of support for collaboration by a large number of countries having Mediterranean climatic conditions (but not necessarily bordering on the Mediterranean itself), the sub-project was formed in 1976 and held its initial meeting in 1977, with experts from ten countries participating. The focus of this group is passive heating and cooling, adaptibility of traditional regional architecture to active and passive systems, and additional related aspects of solar utilization in Mediterranean-type climatic regions. This group will holds its second meeting during the Fall of 1978 and will continue its cooperative efforts during the follow-up period.

ACCOMPLISHMENTS

The activities of the CCMS Solar Energy Pilot Study have resulted in a number of significant accomplishments:

- Positive influence on the development of national solar heating and cooling programs in the participating countries. Access to information on program strategies served as a catalyst for formation of formal heating and cooling programs in a number of countries and expansion of existing programs.
- Augmentation and acceleration of R & D activities in individual countries by the sharing of details on experimental projects.
- Development of a system performance reporting format which provides guidelines for precise and complete reporting of essential data.
- Adoption of the format by the IEA Solar Heating and Cooling Program and the national programs of a number of participating countries.
- Significant expansion of the data base for system performance by the preparation and distribution of reports on measured performance.
- Establishment of an effective forum (the Zero Energy House Group) for detailed interchange on solar-assisted low-energy dwelling projects underway in CCMS countries.
- Compilation and distribution of a report on the state-of-the-art in solar-assisted minumum energy dwellings.
- Initiation of the first multilateral collaboration in passive heating and cooling and related solar applications for Mediterranean-type climatic regions (Mediterranean Application Group).
- Establishment of an information exchange system to facilitate internal dissemination within member countries of distributed reports.
- Exchange of over 70 solar heating and cooling reports, aside from system performance reports, covering a wide variety of subjects.
- Sponsorship of a major International Solar Energy Conference on the Performance of Solar Heating and Cooling Systems. The conference proceedings (CCMS Report #85) will enable a large international audience to benefit from the results of a wide variety of system research projects.
- Establishment of enhanced communication among solar experts and close working relationships between the researchers and program officials of different countries.

RESOLUTIONS AND RECOMMENDATIONS

Based on the extensive interactions within the Solar Energy Pilot Study since its inception, and in view of its objectives and accomplishments, resolutions and recommendations have been put forward by the pilot study. The first is a series of resolutions which affirm the desire to continue the spirit and substance of international cooperation in solar heating and cooling of buildings. Secondly, recommendations for continued international collaboration during the two-year CCMS follow-up period have been adopted. Finally, a set of recommendations has been set forth on technical and programmatic actions at the national level which, if implemented within the participating countries, would augment and expand the value of the Pilot Study.

Resolution on Cooperation in Solar Energy Development

The participating countries:

Concerned that conventional sources of energy are being rapidly depleted,

Recognizing that the use of fossil fuels is adversely affecting the human environment,

Recognizing, further, that solar energy offers a realistic near and long-term alternative energy source,

Considering the conclusions and recommendations set forth by the participating countries and expert groups,

Resolve:

- To work together, with other nations, and within appropriate international organizations, to further the development of cost-effective applications of solar energy for space heating and cooling and domestic hot water heating in buildings;
- to exchange information on the status of national solar energy programs in heating, cooling, and domestic hot water supply in buildings;
- to exchange performance data and results of solar heating and cooling research projects;
- to encourage periodic international conferences, meetings, and symposia for the purpose of exchanging information on national solar energy programs and exchanging data and results from solar heating and cooling experiment;
- to take appropriate steps to remove barriers to the development of solar energy applications in buildings, and agricultural and industrial heating processes.

Recommendations for Action at the International Level

After extensive review and discussion, the pilot study participants unanimously agreed to specific actions to be carried out during the follow-up period. These actions relate to the major elements of the pilot study.

SYSTEM PERFORMANCE REPORTING FORMAT

Recognizing the strong commitment of CCMS Solar Energy Pilot Study participating countries to the exchange of format reports on the measured performance of solar heating, cooling, industrial process, and domestic hot water systems, the existence of the CCMS information exchange network, and the progress of the International Energy Agency (IEA) Task I Sub-group in refining the 1975 CCMS Format,

It is hereby recommended that

- the work of the CCMS Solar Energy System Reporting Format Committee be terminated and the modifications of the format be continued under Task I of the IEA Solar Heating and Cooling Program,
- the CCMS System Performance Reporting Format, the Format Summary Outline, and the existing comments on improving the CCMS Format be transmitted to IEA - Task I,
- subsequent to drafting of the IEA System Reporting Format (based on the CCMS Format and Summary Outline), the IEA draft be distributed via the CCMS information exchange network,
- the CCMS participants suggest to the IEA Format Committee the title "Solar Heating and Cooling System Performance Reporting Format," which is neutral with respect to IEA, CCMS, or any other affiliation,
- the CCMS participants transmit their comments on the new Format to the CCMS Pilot Study Director,
- continued preparation and distribution of system performance reports be encouraged and that the reports be prepared following the CCMS Summary Outline and/or the CCMS System Reporting Format until the IEA completes the new format, after which time the latter format would be available for utilization by the CCMS participants,
- during the follow-up period CCMS participants report on their use of the format to the Pilot Study Director.

ZERO ENERGY HOUSE GROUP

In recognition of the valuable and practical work done by this group, the on-going collaboration of all its members in IEA, and in view of the continuing interest in the results of projects carried out under its auspices by a large number of the pilot study participating countries,

It is hereby recommended that

- the IEA be requested to approve the transfer of the work of the Zero Energy House Group to the IEA Solar Heating and Cooling Program,
- the IEA be requested to provide annual status reports on the group's activities to the CCMS Solar Energy Pilot Study Director during the two-year follow-up period,
- the IEA be requested to hold at least one open technical conference on Solar-assisted minimum energy dwellings, around the end of the CCMS follow-up period.

MEDITERRANEAN APPLICATIONS GROUP

In view of the later commencement of the work of this group and its significant remaining tasks to be accomplished, and considering the current participants and potential participating countries who are not currently involved in such work in any other international forum,

It is hereby recommended that during the follow-up period of two years

- this group continue its cooperative efforts aimed at quantitative simulation and experimentation in solar houses in Mediterranean-type climates, principally based on passive heating and cooling systems,
- the possible transfer of this activity to another international organization be explored, with the condition that all present members be allowed to continue participating in the group and other countries be permitted to join,
- the CCMS Pilot Study participants be regularly informed about the possibilities for such a transfer and, if no single organization proves feasible, consider further work within the CCMS framework.

REVIEW OF NATIONAL SOLAR HEATING AND COOLING PROGRAMS

Given the expression of interest in and assessed value of the annual reports on national solar heating and cooling programs, the existence of a well-established international professional organization with one of its objectives the sharing of information on solar energy programs and applications, and the success of the existing CCMS information exchange program,

It is hereby recommended that

- during the 2-year follow-up period the continued circulation of written status reports on national solar heating and cooling programs be encouraged,

- the transfer of this activity to the International Solar Energy Society be explored, with the intention that presentation of national solar heating and cooling plans be continued at a special session of the bi-annual meetings of the International Solar Energy Society. The CCMS Solar Energy Pilot Study would encourage (a) preparation of reports according to a recommended content outline, (b) consideration of smaller, more specialized meetings for the review of these national programs, and (c) the issuance of a proceedings document for national programs reports (as a separate document or as one of a series of documents resulting from the ISES Conference).

MEMORANDUM OF UNDERSTANDING

It is recommended that the Memorandum of Understanding continue in effect during the two-year follow-up period. The continuation or termination of the MOU at the end of the follow-up period will be addressed prior to the preparation of the final Follow-Up Report (October 1980).

Recommendations for Action at the National Level

While the structure, magnitude and scope of the national programs in each participating country vary significantly, the following recommendations seek to strengthen the technology base for solar heating and cooling. It is therefore recommended that each participating country:

- expand the scope of its solar heating and cooling program to address the full range from R&D to the development of marketable systems for use within its own country, or for export markets.

- conduct comprehensive systems studies to identify those solar heating and cooling systems that have the greatest potential for cost-effectiveness within their country, or climatic region, or for application in other areas.

- continue to identify market and institutional barriers to the widespread use of solar heating and cooling systems and to explore ways to mitigate their effect.

- continue to design, build and evaluate solar heating and cooling systems, using the CCMS System Reporting Format to document the results.

- stress the involvement of manufacturers in the development of integrated water heating, space heating and combined heating and cooling systems, based on traditional market research.

- conduct system performance experiments of minimum energy buildings that use solar to meet the reduced heating and/or cooling load.

- expand the development of passive heating and cooling systems by additional performance and evaluation, information dissemination, and preparation of appropriate design tools.

- expand the solar heating and cooling information dissemination capabilities to address the needs of the full range of users.

- continue and expand efforts to obtain the data necessary to validate system performance predictions for the full range of climatic regions, systems and building types.

- continue to develop components having improved performance, durability and reliability, lower cost, and greater commercial potential.

CONCLUDING REMARKS

This Final Report marks the conclusion of the formal phase of the CCMS Solar Energy Pilot Study. Following the final pilot study meeting, the Contact Persons were asked to assess the effectiveness of this cooperative program. While many specific comments were provided (as summarized on p. 56-59 of this report), the overall assessment was that the collaborative efforts of this project have made important contributions to the advancement of solar energy and that the pilot study was a successful undertaking.

A two-year CCMS follow-up period will now begin, during which many elements of the pilot study will be continued in various international forums. The implementation of the follow-up recommendations will ensure that the work initiated within this pilot study will continue to bear fruit through action at both the national and international levels.

REVIEW OF NATIONAL SOLAR HEATING AND COOLING PROGRAMS

REVIEW OF NATIONAL SOLAR HEATING AND COOLING PROGRAMS

A major element of the Solar Energy Pilot Study was the review of the national solar heating and cooling programs of the participating countries at each of the annual pilot study meetings. Four such meetings were held: Odeillo, France in 1974; Palo Alto, California, U. S. A. in 1975; Copenhagen, Denmark in 1976; and Düsseldorf, Germany in 1978. These meetings provided a unique forum for exchange of information on the status of solar programs and activities in a large number of countries. The presentations enabled delegates to view the scope and contents of their own projects against those of other countries and to note opportunities for strengthening and expansion of their programs and for closer cooperation, both within and apart from the pilot study.

The reports presented during the course of the pilot study reflected a clear evolutionary process which occurred in the development of the majority of solar heating and cooling programs. At the first meeting in 1974, only a few countries had official solar energy programs; the majority were conducting R & D experiments. Over the next few years, a definite pattern unfolded: Additional countries defined a formal solar energy program, which in turn included, or more likely emphasized, solar heating and cooling. R & D activities were then expanded and demonstration projects were undertaken. This led to increasingly ambitious solar programs of broader scope and magnitude. More recently, a number of countries have begun to focus on such non-technical issues as barriers and incentives and consumer protection. Some governments are also working closely with industry to assist in commercialization and market development. The recent status reports appear to indicate increased commitment to solar utilization and confidence in near and long-term solar heating and cooling technical feasibility and cost-effectiveness.

Table 1 reflects the changing status of the solar heating and cooling programs of the signatories to the Memorandum of Understanding, from 1974 through 1978. Table 2 contains a brief summary of the current emphasis of the solar heating and cooling programs of those countries which participated in the 1978 meeting. Further details on their programs may be found in the proceedings of the annual meetings (listed in Appendix E).

While increased global awareness of the need to develop alternative sources of energy and the potential of solar energy for heating and cooling to replace fossil fuels were undoubtedly important factors in the development of the programs of participating countries, the CCMS exchange on national programs clearly influenced the direction taken by many programs and contributed to the expansion and acceleration of these programs. A number of countries modeled their programs after existing programs in other CCMS countries. Furthermore, government planners and technical experts were encouraged to expand R & D into new areas after learning of successful experiences in other nations.

The review of national solar programs was also led to expanded interchange

within the pilot study by the creation of two successful sub-projects having specific regional emphasis. At the 1974 meeting, it became apparent from the status reports that certain groups of countries, with similar climatic conditions and building needs, were stressing similar solar applications. This led to the formation of the Zero Energy House Group, comprised of northern latitude countries experimenting with solar-assisted low-energy dwellings. A second sub-project, the Mediterranean Applications Group, was established in 1976 with the objective of cooperative exchange in passive heating and cooling and other applications for Mediterranean-type climatic conditions. (Detailed information on these groups is contained in other sections of this report.)

The participating countries have pointed to the exchange of information on national solar heating and cooling programs as being an aspect of the pilot study which had significant impact on the development of their own programs.

Table 1
SUMMARY OF THE STATUS OF THE SOLAR HEATING AND COOLING
IN BUILDING PROGRAMS OF THE SIGNATORY COUNTRIES

COUNTRY	1974 (Odeillo) STATUS	1975 (Palo Alto) STATUS	1976 (Copenhagen) STATUS	1978 (Dusseldorf) STATUS
Australia	No formal program - many projects underway.	No formal program - many projects underway.	No formal program - many projects underway.	RD&D supported by national and state governments. National program expected to be developed.
Belgium	Program being formulated.	Program initiated.	Program underway and several projects initiated.	Initial 3-year nationally funded R&D program nearing completion.
Canada	Need for solar not established.	Program initiated and several projects started.	Program underway with increased funds and projects.	R&D program continues with 8-fold increase in funding since 1976.
Denmark	Program underway involving several projects.	Program underway involving several projects.	Expanded program underway.	Increased funding and additional projects in national program.
Federal Republic of Germany	Program initiated - several projects underway.	Program significantly expanded.	Program continues to expand significantly.	Large scale program for R&D and government support of industry.
France	Program being formulated-several projects underway.	Program initiated and projects significantly expanded.	Program continues to expand significantly.	Solar Energy Agency established to coordinate large national program and government and private projects.
Greece	No formal program.	Program initiated.	Limited program underway.	
Israel	No formal program.	Program initiated and several projects started.	Program underway with initiation of new projects.	Program continues government supported research by universities and industry.
Italy	Program being formulated.	Program initiated - several industrial projects underway.	Not present.	Expanded CNR program with increased funding.

COUNTRY	1974 (Odeillo) STATUS	1975 (Palo Alto) STATUS	1976 (Copenhagen) STATUS	1978 (Dusseldorf) STATUS
Jamaica	Observer.	Program being formulated.	Not present. Limited program initiated.	Limited program continuing.
The Netherlands	No formal program- Several projects being initiated.	Program being formulated - additional projects underway.	Program being formulated - projects continuing.	Expanded funding and RD&D activities. Formal program to be initiated shortly.
New Zealand	Not present.	No formal program.	Not present.	No formal program, but government support of R&D activities.
Spain	Not present.	Program being formulated.	Program being formulated - several projects underway.	National coordination of funding and expanded activities underway. Formal program to be initiated in 1979.
United Kingdom	No formal program - several projects underway.	No formal program - additional projects initiated.	Not present.	Four year government program underway.
United States	Program underway involving many R&D and demonstration projects.	Significant growth in program.	Significant growth continues.	Further expansion of large, multi-faceted program, with emphasis shifting towards accelerating the commercialization of solar systems.

Table 2
CURRENT EMPHASIS OF THE SOLAR HEATING AND COOLING
IN BUILDING PROGRAMS OF THE PARTICIPATING COUNTRIES

AUSTRALIA	Priority in energy research is being given to projects which will either conserve or replace oil. Solar heat generating systems have been developed to the stage where they can now be used on a large scale for industrial process heating and heating and cooling of homes and offices,which are the most promising applications. Research, development and demonstration (R D & D) programs are supported by the Australian Government and the State Government of Victoria, South Australia and Western Australia. The work is carried out in CSIRO and a number of universities and colleges of advanced education. A demonstration installation is in operation in a soft drink factory and others are either under construction or being planned. These will show what can be done now with known technology and enable performance to be measured under operating conditions. Annual expenditures for R D & D in 1977/78 is about $2 million.
BELGIUM	A nationally funded R & D program to study the feasibility of solar energy for space and water heating is nearing the end of its first three-year period. In the same area of applications, research is being conducted as part of EEC and IEA energy programs. This work is being done at the Katholieke Universiteit Leuven and at the Faculte Polytechnique de Mons. Some emphasis is also being placed on solar-assisted heat pump systems, hybrid photovoltaic-thermal solar systems, chemical reaction storage, and collector testing procedures.
CANADA	A new Solar Energy Projects Office within the NRC has been established to administer the federal solar heating program which has had an eight fold increase in funding since 1976. Major supported activities include feasibility studies, development of a solar data base, R & D projects and a demonstration program. Earlier support for demonstration of solar systems in detached homes has expanded to solar space and/or service hot water heating for multi-unit residential buildings and next year will include non-residential buildings. A wide variety of component and system R & D studies are underway, both at the NRC and by contractors. Several provincial governments have their own solar energy program as well. Between 15-20 small companies are manufacturing Canadian solar collectors.
DENMARK	For a five-year period, $6 million have been allocated for solar heating R and D and a low-energy housing program. 15 industry and government sponsored demonstration projects are being monitored. A total of about 5000 m^2 of solar collectors have been installed in private homes. The research program includes the following projects: outdoor test stand for solar collectors, indoor solar simulator, test facilities for solar heating

Table 2 continued

	systems, solar energy storage in the ground, experimental investigation of a full scale heat storage with salt hydrate based on the extra water principle, and solar-powered solid-absorption refrigeration system for developing countries.
FRANCE	The French program for solar heating and cooling of buildings is essentially made up of four elements: (1) the CNRS research program (physiology of comfort, system modelling and experimentation, collection and storage components, cooling); (2) the Plan-Construction (Ministry of Equipment) research and experimentation program (thermal storage, climatology, architecture of dwellings and urban shapes, improvement of existing buildings, experimentation of a collective dwelling); (3) the demonstration program of the Delegation aux Energie Nouvelles (Ministry of Industry) which amounts to 25 MF in 1978, for funding of residential and non-residential projects; and (4) some private programs such as those of St. Gobain, COSTIC and Compagnie Francaise de Raffinage. The total budget is approximately 60 MF for 1978, i.e., one third of the total national budget for solar energy R & D. Effective May 1978, a new "Commissariat a l'Energie Solaire" coordinates the national solar program.
FEDERAL REPUBLIC OF GERMANY	By December 1977, the industry-based and government cost sharing solar energy programme had expanded to 53 projects -- 32 related to hot water supply and heating of buildings. Sixteen buildings with extensive data acquisition and evaluation systems are in operation. More than 100 firms are marketing hot water and heating systems. Several fiscal support actions facilitating the installation of solar systems in private and governmental buildings have become effective. Research activities are focused on the development of durable selective surfaces and on the establishment of standardized qualification methods for solar energy components, including system safety.
ISRAEL	Government supports industry 50% in 20 projects in hardware development, large-scale solar water heating systems, materials technology (selective surfaces, plastics), and bio-processes (conversion of agricultural wastes and development of halophylic algae as a fuel source). Two "national" projects (80% support) continue, one for development of solar climate control including cooling machines and one on solar ponds for temperatures up to 100°C for heating, cooling and other uses. Exploratory R & D (100% support) is also conducted on collectors, greenhouses and non-SHCB applications such as photovoltaics and photochemistry.
LUXEMBOURG	Solar Energy research was initiated by Luxembourg industry in 1974. Government has been supporting industry R & D for solar collector development and solar-assisted heat pump systems since 1976.

Table 2 continued

MONACO	Local industry is developing and testing 2 types of concentrating, tracking collectors and 1 non-imaging concentrating collector. Design and testing of vacuum insulated tubes for these collectors is underway, as well as high temperature storage systems.
NEW ZEALAND	The New Zealand climate and the pattern of energy use has dictated that domestic solar water heating should be the first topic for Government sponsored solar research. Modelling and computation of domestic solar water heater performance in all major NZ towns was completed in 1965. Testing of solar collectors and solar water heating systems continues. Space heating on a single-house scale is not favoured because of the small energy demand, but centralised space and water heating in the domestic and industrial sectors is being investigated. Thus, solar energy is diverted towards providing low grade heat so that high grade energy (electricity) currently used for this purpose can be freed for more demanding purposes.
SPAIN	Since 1977 activities in solar energy have been coordinated and financed through the Centro de Estudios de la Energia (CEE). A national program is being prepared for 1979 with an estimated budget of 400 MPta (25M $), with about 15% devoted to heating and cooling projects. The CEE is conducting a survey study to identify industrial applications of solar energy, and demonstration projects are being planned. Other institutions -- INTA, Services Meteorologie Nacional, SCIC and INI -- are also involved in solar energy projects. Private industry activity in solar energy is expanding with about 20 firms currently engaged in this trade. An 18-story building with 10,000 m^2 of floor area incorporating 1,800 m^2 of vertical active air collectors began operation in October 1977.
SWEDEN	A solar R & D and demonstration program will be included in the national energy program for 1978-81. Heating of swimming pools and hot water heating are first option of interest. Five solar heated outdoor public swimming pools will be sponsored and evaluated. At least two large-scale (more than 50 dwellings) solar space heating systems based on central seasonal thermal storage will be built during program period.
TURKEY	The solar energy program, initiated in 1976, is coordinated by Ministry of Energy and Natural Resources and carried out by the Mineral Exploration and Research Institute at "Marmaris Solar Energy Research Center." The major project at the Research Center related to solar heating and cooling of buildings has four phases: heating of two types of village houses and heating and cooling of single-family and apartment dwellings. The first phase of the project has been in operation since September 1977. Additional activities continue on collection of climate and solar data, solar drying, greenhouse heating, solar collectors, development of selective surfaces, and solar distillation. Scientific and applied research carried out at universities and research institutions include solarimetry studies, testing of

Table 2 continued

	buildings solar drying, desalinization, architectural research, solar collectors, energy storage, and solar cells.
UNITED KINGDOM	Government Departments in the United Kingdom are collaborating in a four-year programme aimed at the comprehensive assessment of the contributions likely to be made to national energy supplies by the exploitation of solar technology, against alternative rates of rise in world energy prices. Low-grade thermal applications are foreseen as the most significant uses of solar energy in UK, and the greater part of the £6 million programme announced in February 1977 by the Department of Energy is likely to be devoted to space and water heating in buildings. Other Central Government funds are being made available by the Department of the Environment (with its own solar research facilities at the Building Research Station), the Department of Industry, and the Science Research Council. At least 40 projects in this field are in progress at universities, government laboratories, local authorities and commercial enterprises; Government participation varies from co-ordinating discussion of results, to full funding of costs.
UNITED STATES	The goal of the U. S. Solar Heating and Cooling Program, directed by the Department of Energy, is the advancement of industrial, commercial and professional capability for producing and distributing solar energy systems, thus reducing the demand on fossil fuel supplies. The major elements of the heating and cooling program are: research and development; residential and commercial demonstrations; agricultural and industrial applications; federal buildings program; technology transfer; and commercialization. The R & D program has expanded to 244 projects, most of which are aimed at improved performance and cost-effectiveness. The four cycles of demonstration awards have funded several hundred residential and commercial projects. Strong emphasis has recently been placed on market development to accelerate the commercialization of solar heating and cooling.

CCMS SYSTEM PERFORMANCE REPORTING FORMAT

CCMS SYSTEM PERFORMANCE REPORTING FORMAT

PURPOSE

The CCMS Solar Energy Pilot Study was initiated to facilitate the international exchange of information on solar heating and cooling systems. At the outset, it was recognized that a key element of the information exchange would be the availability of precise and complete information on the actual measured performance of such systems. The sharing of such detailed information on the design and performance of experimental projects in a number of countries would serve to supplement the research activities of each participating country. It was recognized that to ensure inclusion of adequate and complete information, specifications for reporting performance data must be devised. The objective of such a format would be to guide preparers of system performance reports in order to assure that sufficient information is provided to enable the reader to make his own assessment of the measured performance of a solar heating and/or cooling system and to relate that measured performance, which was carried out in one particular climate and economic environment, to a similar or different climate and economic environment.

Therefore, at the 1974 Solar Energy Pilot Study Meeting in Odeillo, work on the draft of a format for reporting measured performance was initiated and a System Reporting Format Committee formed. The Committee was originally chaired by Dr. F. Morse, U. S., and subsequently by Dr. R. Allen, U. S. A series of drafts were prepared, circulated, and reviewed. In 1975 at the Palo Alto meeting, a format was adopted as the Recommended CCMS System Reporting Format, with the understanding that the recommended format would be used for one or two years and then revised as necessary. Implicitly, a format undertaking in solar heating and cooling assumes the professional technical community will gradually adopt, absorb, and refine the method and its definitions.

CONTENT

The CCMS Reporting Format defines the "system" broadly so as to encompass the building, the conventional heating/cooling and domestic hot water equipment, as well as the solar components. Systems covered include both active and passive solar space heating, space cooling, and domestic hot water in buildings, as well as industrial applications of solar energy as a source of process heat. The aspects covered include not only the measured thermal performance in active, passive, and auxiliary modes, but also the site features, the thermal environment, the building shell characteristics, and economic data.

The CCMS Reporting Format, the text of which may be found in the Appendix of this report, is divided into the following sections:

- General Description of System Project and Environment
- System Thermal Performance
- System Economic Analysis
- Major Conclusions
- Sub-System Performance Reporting Format.

A typical performance report on a space heating and/or cooling system, prepared in accordance with the format, opens with a brief description of the objective and strategy of the project being reported. This is followed by a description of the project location and the major dimensions and features of the building site that bear on the performance of the system. A brief, general description of the environment is given, followed by the system description, starting with the building thermal envelope and its heating and cooling load characteristics followed by a description of the hot water load. The heat/cooling/hot water and solar equipment is then described with the aid of a general system configuration diagram, and major dimensions of collector, storage, and other components are given. In successive general system configuration diagrams, operating modes, control sensor locations, and measurement points are given.

The System Thermal Performance section gives energy-flow and performance-factor definitions. Energy flows are presented on a system configuration diagram, and system thermal performance results are discussed in terms of daily, monthly, and annual quantities and in terms of the quality of the indoor climate maintained, making use of the established measures of comfort of occupied space including spatial and time variations.

The recommended reporting of the system economic analysis is typically approached at two levels. On the first level, cost data and local rates of taxation, interest, and inflation may be stated. On the second level, results of cost analyses are to be described and a description of the economic model and assumptions included.

The Major Conclusions section covers the major results and experiences. The format on sub-system characteristics and performance provides subsidiary details on key components within, and as part of, the system.

HISTORY AND ACCOMPLISHMENTS

Following its initiation at Odeillo in 1974 and its adoption at the Palo Alto Meeting in 1975, the CCMS Reporting Format was introduced into the CCMS information exchange network. By mid-1976, five Format Reports on building heating/cooling/domestic hot water systems had been prepared and distributed to the CCMS Contact Persons. At the 1976 Pilot Study Meeting in Copenhagen, oral reports were given covering seven complete and published Format Reports, and progress reports were given on trial applications of the Reporting Format. Altogether, eight countries were participating in these applications of the Format. By 1977, interim or complete Format Reports on a total of fourteen different heating or hot water systems had been published and introduced into the CCMS information network. These are listed in Table 3.

Fig. 1. A 600 m^2 collector array supplies heat to a heating and cooling system in the Community Center in Santa Clara, California, USA.

Fig. 2. Highly insulated walls, improved window insulation and heat recovery from exhaust air and waste water are featured in the solar heated Termeroc House in Limhamn, Sweden.

At the 1976 meeting of the Format Committee in Copenhagen, a number of suggested modifications to the Reporting Format were received and the need for a Format Summary Outline was identified. A Format Summary Outline was desired to provide guidelines for preparation of a summary or extended abstract to accompany the full, more detailed system performance report. The meeting participants formally recommended that (a) the format not be modified for the moment and (b) Format Summary Outline be drafted and circulated. A Format Summary Outline draft was subsequently prepared, circulated, modified, and put into use as the basis for abstracts of the system performance reports published in the extended abstracts for the 1978 CCMS/ISES Conference in Düsseldorf.

The CCMS/ISES International Conference on the Performance of Solar Heating and Cooling Systems* held in April 1978 (following the annual Pilot Study Meeting) provided impetus for expanded application of the CCMS Reporting Format. The Conference was convened to provide a forum for the presentation of solar heating and cooling system performance data. The meeting was an international public presentation of sixteen format reports from ten countries (listed in Table 3). A final proceedings document containing these performance reports has been published and distributed (CCMS Report #85). The authors were unanimous in endorsing the general value of the CCMS Format as a useful guide to the writer, although they held divergent views on the need for a specific chronology and a set of concrete definitions.

The importance of the CCMS contribution in the performance reporting format area is underscored by the adoption of the format by another international solar program and by several national solar programs. By 1976, the Solar Heating and Cooling Program of the International Energy Agency (IEA) had undertaken a task in system performance studies. In connection with that task, the IEA adopted the CCMS Reporting Format as a basis for the design of a more detailed format to be used within the IEA program. Also, it is significant that at an earlier date, the United States had adopted the format and modified it for use in the U. S. Solar Heating and Cooling Demonstration Program.

In 1977, the Swedish CCMS observer group distributed to the pilot study information exchange system a document containing extensive comments on the application of the CCMS Format, based on Swedish experience in applying the format. Subsequently, a Swedish IEA team drafted a preliminary IEA Reporting Format. Liaison and assistance was provided by the CCMS Format Committee in 1977 and 1978.

The desirability of liaison between the CCMS Format Committee and the IEA Format Task Group was underlined at the 1978 CCMS Solar Energy Pilot Study Meeting in Düsseldorf. The Format Committee report reviewed the comments on the format that had been received from several countries. It was recommended that these comments be transmitted to the IEA Format Group for its guidance in the preparation of a second IEA Format draft during the summer of 1978. In subsequent discussions at the meeting on pilot study follow-up activities, it was formally proposed that CCMS recommendations pertaining to format modification be transferred to the IEA Format Group and that any further international work on revision of the Format be conducted within the IEA. It was also proposed that the CCMS Reporting Format continue in force during

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* Co-sponsored by the CCMS Solar Energy Pilot Study and the German Section of the International Solar Energy Society (ISES)

the follow-up period to allow time for phasing in the IEA Format. Since authors and potential users appeared to want both flexibility and guidance at the same time, it is likely that the IEA will draft a document with both features.

This second-generation format will then be, in large part, the product of the CCMS pioneering effort in devising and applying a format for reporting the measured performance of solar heating and cooling systems. It will hopefully result in an internationally accepted and utilized specification for system performance reporting.

Fig. 3. The solar system of the Dornier/RWE House in Essen, FRG consists of a 65 m^2 heat pipe collector, seven storage tanks, and a heat pump.

Table 3. CCMS SYSTEM PERFORMANCE FORMAT REPORTS

	YEAR	INTERIM FORMAT REPORT	SUMMARY FORMAT REPORT	FORMAT REPORT
AUSTRALIA				
Three Public-Facility hot water systems	1976	•		
Industrial process hot water system	1978		•	•
CANADA				
Provident house heating system	1976	•		
Mississauga house heating system	1976,1978	•	•	•
DENMARK				
Zero Energy house heating system	1976,1978			
FEDERAL REPUBLIC OF GERMANY				
Dornier/RWE house heating system	1978		•	•
MBB house heating system	1978		•	•
Phillips experimental house system	1978		•	•
Outdoor swimming pool heating system	1978		•	•
FRANCE				
Odeillo house heating system	1976			•
Blagnac house heating systems	1978		•	•
THE NETHERLANDS				
Eindhoven house heating system	1978		•	•
NEW ZEALAND				
Titahi Bay house heating system	1978		•	•
SWEDEN				
Limhamn house heating system	1976,1977	•		•
Linkoping house heating system	1976,1977	•		•
Vetlanda passive house heating system	1976,1978	•		•
TURKEY				
Marmaris passive house heating	1978		•	•
UNITED STATES				
Industrial process hot water system	1976			•
Colorado Springs house heating system	1976			•
Minnesota high school heating system	1976			•
Atlanta elementary school heating and cooling system	1976			•
Colorado State University House I heating and cooling system	1976			•
Southern California apartment hot water system	1976			•
Boston high school heating system	1976			•
Colorado State University House II	1978		•	•
Santa Clara Community Center heating and cooling	1978		•	•
Colorado State University House I heating and cooling with evacuated tube collectors	1978		•	•
Los Alamos Study Center heating and cooling system	1978		•	•

CCMS/ISES CONFERENCE ON THE PERFORMANCE OF SOLAR HEATING AND COOLING SYSTEMS

CCMS/ISES CONFERENCE ON THE PERFORMANCE OF SOLAR HEATING AND COOLING SYSTEMS

The CCMS/ISES Conference on the Performance of Solar Heating and Cooling Systems was planned as a forum for the delivery of reports prepared according to the CCMS System Reporting Format. The conference, held on April 19-20, 1978, at the Congress Center, Düsseldorf, Federal Republic of Germany, was the first international conference devoted exclusively to the reporting of the measured performance of solar heating and cooling systems in buildings and the first public technical conference sponsored by the CCMS Solar Energy Pilot Study. It was co-sponsored by the German Section of the International Solar Energy Society (ISES), with assistance provided by the German Ministry of Research and Technology, the Kernforschungsanlage Jülich, the German Solar Energy Industries Association, the German Solar Energy Society, the Society of German Engineers, and the U.S. Department of Energy. The conference was attended by over two hundred persons.

It is widely acknowledged that, although there are computational methods available for predicting the performance of solar heating and cooling systems, it is the measured performance of the entire system that is needed to substantiate those programs and to firmly establish the place of solar energy application in a country's economy. To insure completeness of system performance reporting in the CCMS information exchange process, the CCMS System Reporting Format was formulated early in the Pilot Study, as described elsewhere in this report. After its adoption, the Format was used by CCMS countries as a guide for preparation of written system performance reports. To further highlight the value of performance reporting and to make the Format more widely known, the idea of a CCMS/ISES conference devoted to measured performance of system projects which had been operational for at least one complete heating and/or cooling season was then conceived and carried out under the direction of the CCMS Solar Energy Pilot Study.

The two-day CCMS/ISES conference, attended by some 200 engineers, scientists, government officials and businessmen, included several survey lectures on the subjects indicated under that heading in Table 4. A lecture on the CCMS System Performance Reporting Format briefly reviewed the purpose and structure of the format emphasizing the main elements of environment, system description, system performance description, economics, and sub-system characteristics. A joint FRG-USA lecture provided an overview of the conference papers in which the reported systems were compared as to type, size and performance. A lecture given on the prospects of solar heating and cooling in the USA set forth the wide array of system types being studied and demonstrated under Federal sponsorship, as well as a summary of the economics of present SHAC systems. An FRG lecture drew a comparison between hypothetical solar and conservation alternatives, showing a technique for establishing the crossover point where the former would be favored over the latter. The advantage of passive systems was discussed and sample of buildings were shown pictorially by a U.S. speaker.

Fig. 4. Solar House I at Colorado State University, USA, utilizes an evacuated tubular solar collector and an absorption chiller for solar heating and cooling. An identical experimental building, Solar House II, uses air heating collectors and nocturnal cooling.

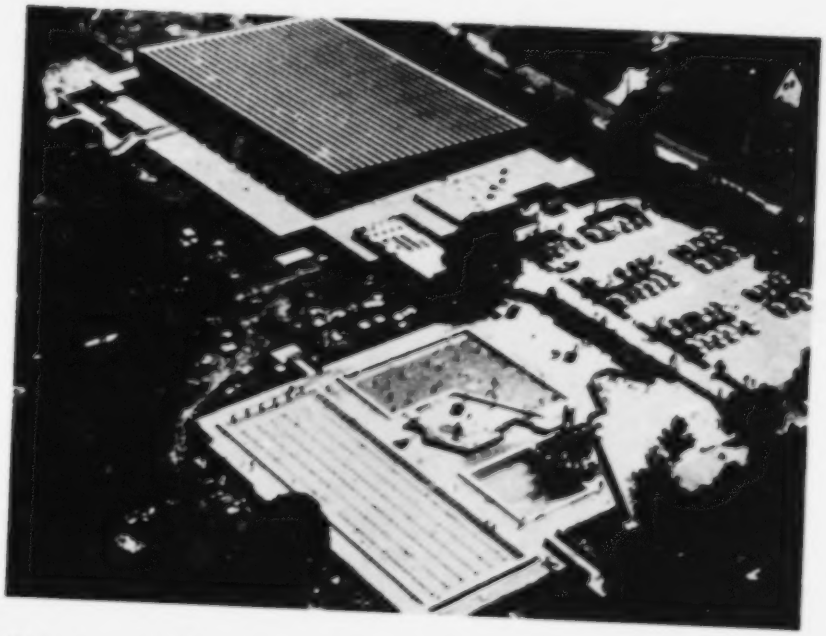

Fig. 5. Heating for an outdoor swimming pool in Wiehl, FRG, is provided by a 1500 m^2 flat plate collector.

The sixteen system performance reports given at the conference spanned residential, non-residential, swimming pool and industrial process solar applications, as listed in Table 3. The collector and load characteristics associated with the systems whose performance was reported are shown in Table 4. In particular it will be noted that only one air-cooled collector was involved. Twelve of the systems supplied space heating while only three supplied cooling. The systems produce usable solar heat in annual amounts ranging from 0.5 to nearly 2 gigajoules per square meter of collector.

Extended abstracts of each performance report prepared in accordance with a Summary Format were available at the meeting. Many speakers found it convenient to adhere to the CCMS Summary Format topics in chronological order in making their presentations. Others made use of the format topics in ways that fit the project being presented. During the presentations, the difficulty of accumulating operating data was widely acknowledged and candidly discussed. Problems, as well as successes in system design and performance, were also frankly reported. Such assessments are essential for pointing out fruitful approaches or mistakes to avoid in carrying out other projects.

Useful informal exchanges took place during the Conference between representatives of the CCMS Format Group and the presenters. In these exchanges, the strengths and weaknesses of the format were noted for the future information of the assigned IEA activity which will continue format development initiated by the CCMS Solar Energy Pilot Study.

A panel discussion at the end of the meeting emphasized: 1) the uniqueness of a meeting at which papers were wholly devoted to performance data on operating solar heating and cooling systems operating over all (or most) of the heating and/or cooling season and the need for additional meetings of this type, 2) the difficulty of accumulating such operating data, and 3) the importance of attaining continuous, long-time data to the general development and application of solar heating and cooling systems.

The proceedings of the conference (CCMS Report # 85) containing complete performance reports, prepared in accordance with the full CCMS System Reporting Format, have been compiled and distributed.

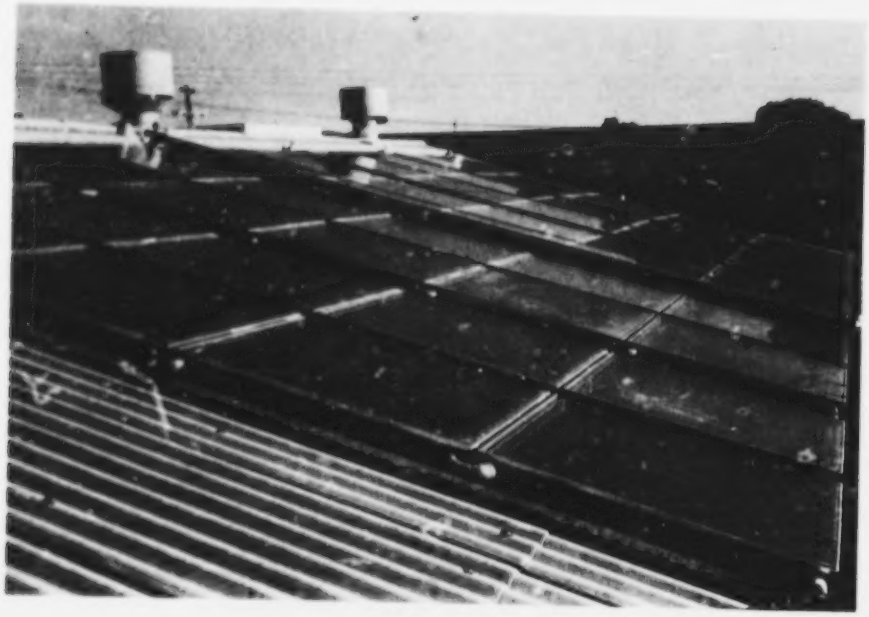

Fig. 6. These roof collectors supply solar industrial process heat for can warming at a soft drink factory in Queanbeyan, Australia.

Fig. 7. Solar heated houses in Blagnac, France are equipped with 30 m^2 flat plate collectors and their performance is compared with nearby identical houses heated with gas.

TABLE 4. CCMS/ISES CONFERENCE PROGRAM

SURVEY LECTURES

The CCMS Format
Overview of Papers
Prospects of Solar Heating and Cooling in the USA
Solar Active Systems or Energy Conservation
Passive Solar Energy Systems

SYSTEM PERFORMANCE REPORTS, RESIDENTIAL BUILDINGS

House II at Colorado State University, USA
Dornier/RWE House in Essen, FRG
Messerschmitt-Bolkow-Blohm House in Otterfing, FRG
House in Mississauga, Canada
House at Titahi Bay, New Zealand
House in Blagnac, France
House of the Technical University, Eindhoven, The Netherlands
Passive Solar House in Marmaris, Turkey
Passive Solar House in Vetlanda, Sweden
House I at Colorado State University, USA
Zero Energy House in Lyngby, Denmark
Phillips Experimental House in Aachen,FRG

SYSTEM PERFORMANCE REPORTS, PUBLIC BUILDINGS

Study Center in Los Alamos, USA
Community Center in Santa Clara, USA

SYSTEM PERFORMANCE REPORTS, OTHER APPLICATIONS

Outdoor Swimming Pool, in Wiehl, FRG
Industrial Process Can Warming in Queanbeyan, Australia

CONCLUSION

Panel Discussion: Denmark, France, FRG, USA
Open Forum

TABLE 5. CHARACTERISTICS OF SYSTEMS REPORTED AT CCMS/ISES CONFERENCE

PROJECT (see also Table 1)	COLLECTOR					APPLICATIONS						ESTIMATED ANNUAL SOLAR ENERGY SUPPLIED, GJ/m^2
	AREA m^2	FLAT PLATE	EVAC-UATED	WATER COOLED	AIR COOLED	SPACE HEATING	SPACE COOLING	HEAT PUMP	SWIM-MING POOL	DOMES-TIC HOT WATER	INDUS-TRIAL HOT WATER	
Queanbeyan,Aust	94	•		•								
Mississauga,Can	64	•		•		•		•		•		1.7
Lyngby, Denmark	40	•		•		•				•		0.8
Blagnac, France	30	•		•		•						0.7
Essen, FRG	65	•(a)		•		•		•	•	•		-
Otterfing, FRG	80	•		•		•				•		1.1
Aachen, FRG	20		•	•		•		•		•		0.5
Wiehl, FRG (b)	1500	•		•					•			0.6
Eindhoven, Neth	51	•		•		•						0.6
Titahi Bay, NZ	33	•		•		•				•		-
Vetlanda, Swede.1		(Passive)				•						-
Marmaris,Turkey		(Passive)				•						-
CSU House I,USA	40		•	•		•	•			•		-
CSU House II,USA	67	•			•	•	•(c)			•		-
Los Alamos, USA	716	•		•		•	•			•		1.5
Santa Clara,USA	660	•		•		•	•			•		1.6

(a) heat pipe
(b) Installation includes space heating, DHW, and heat pump. Swimming pool performance reported at conference.
(c) Nocturnal system

ZERO ENERGY HOUSE GROUP

ZERO ENERGY HOUSE GROUP

BACKGROUND

In the context of the CCMS Solar Energy Pilot Study, a Zero Energy House is one in which solar energy is used to meet the significantly reduced energy needs of buildings incorporating various energy conservation subsystems. Measures to reduce energy consumption include building design; reduction of heat losses through windows, walls, floors, ceilings, and air leakage; and recovery of waste heat from domestic hot water systems and exhaust air systems. The objective of these projects is to study the performance of buildings which require essentially zero or minimal energy from conventional fuels and utilize various active and passive solar heating systems and heat pump systems.

As a result of the interest of many participating countries, particularly those with northern European-type climates, in such low-energy dwellings, a Zero Energy House Group was formed within the Solar Energy Pilot Study in 1974. The group, chaired by Professor Vagn Korsgaard of Denmark, held three meetings in which representatives from seven countries participated: Canada, Denmark, Federal Republic of Germany, the Netherlands, Sweden, United Kingdom, and the United States.

SUMMARY OF ZERO ENERGY HOUSE GROUP MEETINGS

The Zero Energy House Group held its first meeting during January 30-31, 1975, when fifteen representatives met at the Technical University of Denmark in Copenhagen. Each of the participating countries gave a detailed presentation of the status of current projects related to low-energy dwellings.

The second Zero Energy House Group meeting was held at the Philips Research Laboratory in Aachen, Federal Republic of Germany, during May 26-28, 1975. Thirty-six representatives participated in this meeting. There was a detailed discussion of solar collectors and long-term heat storage systems used in low-energy houses.

The third Zero Energy House Group meeting was held at the Royal Institute of Technology in Stockholm, Sweden, during December 8-9, 1977. Nineteen representatives participated in this meeting. The objectives were to discuss experiences and performance measurements of low-energy houses in the participating countries and to inform the participants of recent developments in projects associated with low-energy houses.

LOW ENERGY HOUSE PROJECTS

The status of major low-energy house projects presented and discussed in the Zero Energy House Group is as follows:

Mississauga Solar House

The building is a single-family house with 135 m^2 of living space. The house is designed to utilize the solar heat gain through large south-facing windows. The design space heating load is calculated to 361 W/°C.

The energy system consists of 64 m^2 solar collectors with copper tubes and a copper absorber plate with selective coating. The storage unit consists of two insulated concrete tanks containing 9 m^3 of water each, located in the basement. The bottoms of the tanks are not insulated. The solar energy system is combined with a water-to-air electric heat pump with a heat output of 15 kW.

During 1976/77 the energy system provided 42 per cent (7800 kWh) of the annual space and service water heating requirements (18600 kWh). The heating requirement for space heating was 13000 kWh and for service water 5600 kWh. The annual loss from storage was 62 per cent of the total collected energy.

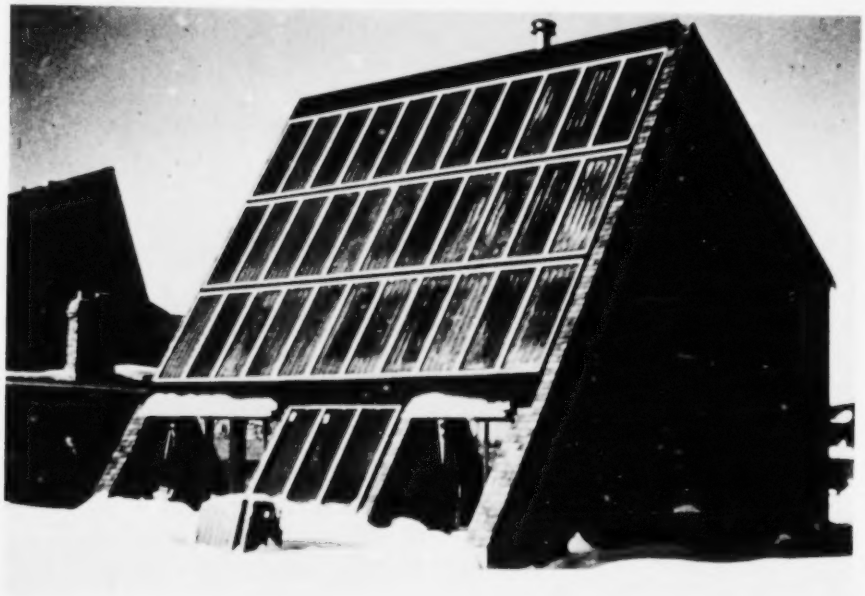

Fig. 8. The Mississauga House in Ontario, Canada utilizes a 64 m^2 collector and solar-assisted heat pump to provide space and domestic hot water heating.

Zero Energy House

The building is a single-family house with 120 m^2 of living space. The house is designed with energy conservation arrangements such as highly-insulated construction, movable insulation of the windows and heat recovery in the ventilating system. The design space heating load is calculated to 125 W/°C. The energy system consists of a 42 m^2 vertical flat-plate solar collector and a seasonal water storage tank with a capacity of 30 m^3.

Fig. 9. The Zero Energy House in Lyngby, Denmark employs many unique energy conservation features plus seasonal storage. The CCMS Zero Energy House Group was named after this pioneering low-energy house.

During 1976/77 the solar radiation was only about 70% of the solar heat gain during the corresponding period in the standard year. The solar heating system provided 37 per cent (3500 kWh) of the annual space and service water heating requirements (9500 kWh). The heat requirement for space heating was 5800 kWh and for service water 3700 kWh.

Low Energy Houses in Skive

In 1977, nine different adjacent low-energy single-family houses were constructed in Skive. Each resident has energy conservation features and a solar heating system. The houses will be monitored during the period 1978-80.

Fig. 10. One of nine low-energy residences with solar heating systems in Skive, Denmark.

Low Energy Houses in Lyngby

Six different low-energy houses are under construction in Lyngby. In this project, a low-energy house is defined as a single-family house, 120 m^2, with a total demand for space heating and service water supply of not more than 5000 kWh per year. The auxiliary heat supply of max. 5000 kWh includes electric supply to ventilators, water-pumps and heat-pumps. The houses will be monitored during the 1978-80 period.

GERMANY

Philips Experimental House in Aachen

The building is a single-family house with 116 m^2 of living space. Considerable reduction in the energy need for heating has been achieved by introducing extra insulation into the walls, floors and ceilings, reducing the uncontrolled ventilation losses and using windows with low heat conduction.

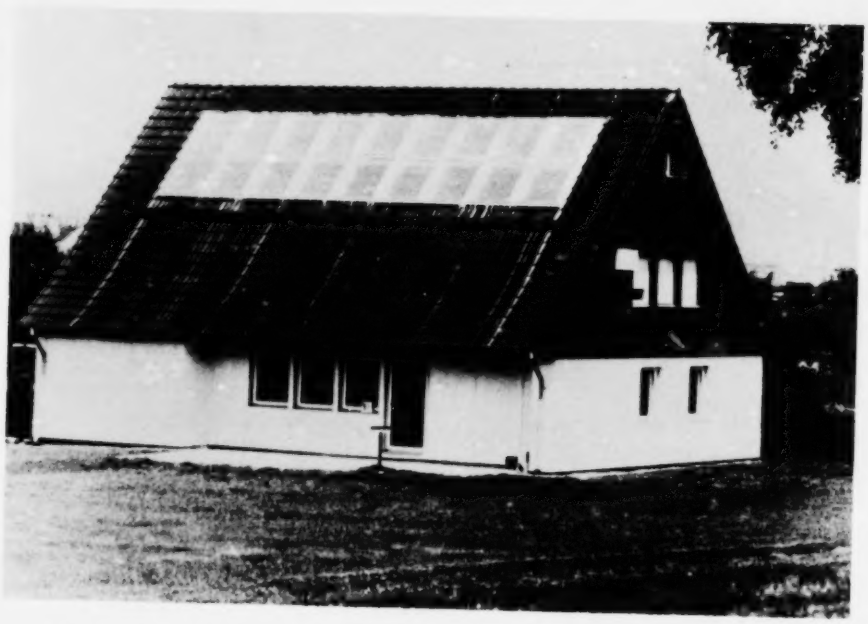

Fig. 11. The Philips Experimental House in Aachen, FRG has tested a number of solar and energy conservation configurations and currently employs evacuated tubular solar collectors and two heat storage tanks.

The solar energy system, consisting of 20 m^2 high-efficiency solar collectors and 2 heat storage tanks of 40 m^3 and 4 m^3, covered 70% (2800 kWh) of the space heating requirements (4000 kWh) in the 1975/76 winter period. A heat pump provides auxiliary heat by extracting heat from the large storage tank and, at times, from the waste water tank.

THE NETHERLANDS

Solar House of the Eindhoven University

The Solar House of the Eindhoven University of Technology is a single-family house with a living area of about 220 m^2. The house is thermally well-insulated in comparison to conventional Dutch houses. The theoretical heat loss coefficient of the walls, roofs, and floors is 0.4 W/m^2 °C, and double pane glazing is applied in all windows. The heat demand of the house is 12 kW at an outside temperature of -10°C and an average inside temperature of 20°C.

The solar heating system is comprised of an integrated solar roof with 51 m^2 of collector area, a heat storage tank containing 4 m^3 of water and a natural gas-fired auxiliary heater. The storage is highly thermally stratified due to a floating inlet for the solar heated water. Temperature differences of 50°C between the top and bottom are not exceptional in winter.

Fig. 12. The Solar House at the Eindhoven University of Technology, The Netherlands, features a 51 m^2 liquid collector for space heating.

SWEDEN

Termoroc House

The experimental low-energy house in Limhamn has a living space of 150 m^2. It utilizes such energy conservation arrangements as well-insulated walls (k-value less than 0.3 W/m^2 °C), improved window insulation, and heat recovery from exhaust air and waste water.

The solar energy system, consisting of 42 m^2 solar collectors and 2 storage tanks of 1.7 m^3 each, supplied 25% (5000 kWh) of the space heating requirement (20,000 kWh) during the 1975/76 winter season.

Solar House in Linkoping

This experimental single-family house in Linkoping has a living space of 160 m^2. The house is insulated according to Swedish standards.

The solar energy system consists of 50 m^2 solar collectors and a storage tank of 8 m^3. During the 1975/76 winter season, it covered 30% (5800 kWh, of the total space heating and water requirements (19500 kWh). The space heating requirement was 16200 kWh and the service water heating requirement was 3300 kWh.

Passive Solar House in Vetlanda

Solar energy is admitted through windows (18 m^2) in the southern facade. High indoor temperatures are avoided by means of room thermostats, a variable air flow and fixed solar screening. Heat losses are reduced by means of effective insulation (19 cm in walls and 30 cm in roofs), four-pane windows and dense construction. The space heating load has been calculated to 7000 kWh per year.

The most serious problem anticipated in this project was high indoor summer temperatures, due to the large south facing glass area. However, no extreme temperatures have been reported during the summer period, probably as a result of the extended roof overhang.

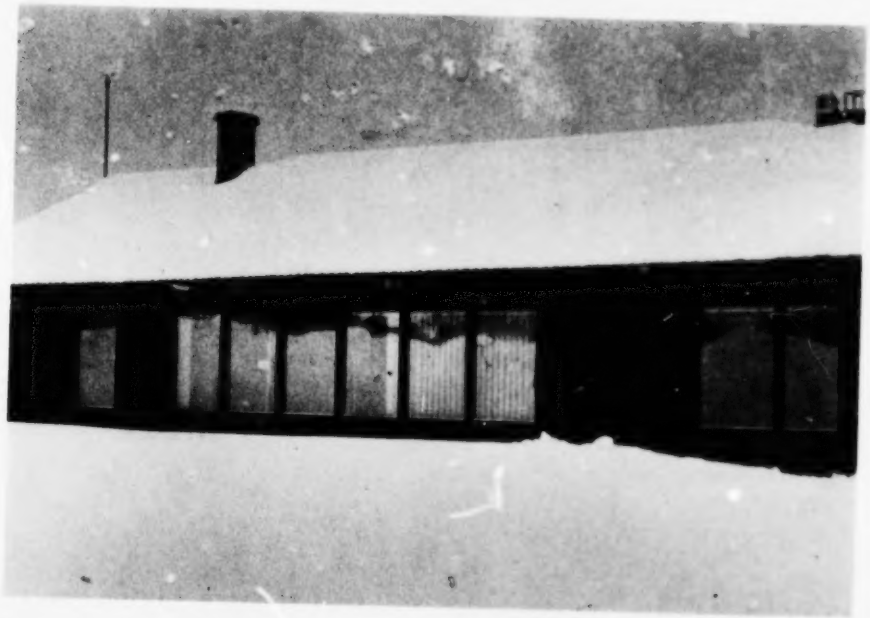

Fig. 13. This single-family house in Vetlanda, Sweden is an example of a passive system in a northern latitude.

UNITED KINGDOM

BRE - Houses

Three low-energy houses have been constructed at the Building Research Establishment in Watford. One house has a flat plate solar collector and a storage system using 3 tanks, one has heat pumps alone, and the third has heat recovery equipment.

Autarkic House in Cambridge

A project to devise a self-sufficient house -- completely independent of the network services of gas, water, electricity, and drainage -- has been underway at the University of Cambridge since 1971. The main objective is the construction of a house deriving its energy and resource requirements from solar and wind power, the collection of rainwater, and the recycling of its own wastes.

UNITED STATES

Goosebrook Solar Home (New Hampshire)

With the aid of energy-conserving design and active and passive solar systems, the heat requirement for the Goosebrook Solar Home is calculated to be less than one-fifth of the heat requirement of normal homes in the same climate.

The active solar system uses water for transporting and storing the heat. The south-facing sloped roof is covered with black corrugated aluminum, single-glazed collectors based on a design by Dr. Harry Thomason. Water trickles directly over the panels, and after being heated by the sun, flows directly, by gravity, to the storage system in the cellar.

The passive portion of Goosebrook's solar heating system is composed of a small greenhouse, an all-glass south wall, and a row of water-filled fiberglass cylinders inside the living-room, next to the glass wall. When sunlight enters the wall, it heats the water in the cylinders. At night the water re-radiates its stored warmth, providing space heat by passive means. To prevent night-time heat loss, the house has movable insulating doors that can cover the exterior of the glass wall at night.

CONCLUSIONS

Dwellings which incorporate energy conservation features are particularly important in northern latitude countries, which have a long heating season but often receive relatively low amounts of solar insolation. Conservation measures can significantly reduce the energy demand to a point where solar energy systems can make an important contribution to meeting the heat load of residential buildings.

The CCMS Zero Energy House Group initiated effective and valuable interchange on solar-assisted minimum energy dwellings. Important information on the design of low-energy residences and the performance results of their solar systems was exchanged. In addition to overall systems, relevant subsystems and components -- such as seasonal storage and heat pumps -- were discussed.

The group meetings also served to identify remaining technical problems and those areas in which further investigation is needed. The following topics are recommended as the subject for future cooperative efforts:

- Economic evaluation of low energy dwellings
  - Approaches to the definition of incremental costs
  - Cost studies
- Cooperative performance measurements in low energy dwellings
  - Study of approaches
  - Measurement of performance
- Cooperative research in seasonal storage, for countries with high heating loads and low insolation.

The participants have praised the collaboration undertaken in the Zero Energy House Group. The group discussions have influenced the establishment of a number of new projects, and had an impact on the specific design characteristics of these projects as well. In addition to the technical exchange, experts have appreciated the opportunity to establish close ties with their colleagues working on similar projects in other countries.

MEDITERRANEAN APPLICATIONS GROUP

MEDITERRANEAN APPLICATIONS GROUP

BACKGROUND

As a result of the successful interchange of the CCMS Zero Energy House Group which shared the experiences of northern latitude countries with low-energy dwellings, it was decided at the 1975 CCMS meeting in Palo Alto, California, to consider the establishment of additional subprojects relating to solar utilization in other climatic regions. The Mediterranean working group was formed as a result of this decision.

At the 1976 pilot study meeting in Copenhagen, the following countries joined to form a Mediterranean Applications Group: France, Federal Republic of Germany, Greece, Israel, Saudi Arabia, Spain, Turkey, and the United States. Subsequently, Australia, Iran, and Italy expressed interest in joining the group. It was made clear that participation was not limited to countries bordering on the Mediterranean, and that all countries with sufficient interest would be welcome to participate. France agreed to lead this group, with Dr. M. Rodot serving as Chairman.

The participants first formulated a definition of the "Mediterranean climate." This has the following characteristics:

- Relatively cool winters
- Short period of heating required, but with many sunny days
- Humid, relatively dry or dry summers
- Cooling frequently required in summer
- An abundance of clear days and nights.

Because of the relatively short heating period, it appeared that active solar heating systems would not be competitive, whereas passive heating methods might be. It was also considered important that cooling during hot periods be accomplished by simple methods, if possible.

The participants then outlined specific facets of solar energy appropriate to this climate, with the intention that many of these applications would be the subject of close cooperation within the group. These applications were:

- Passive heating and cooling systems, designated as the focus of a special effort
- Studies of the traditional living environment, concentrating especially on the material and sociological aspects of regional dwellings

- Cooling methods using evaporation
- Cooling methods using nocturnal radiation and cool night air
- Solar ponds, which may be particularly appropriate to this type of climate
- Techniques for conserving water
- Systems of water distillation, whether or not associated with the production of mineral salts
- Specific aspects of meterology, particularly those bearing on nocturnal radiation.

It was recognized that additional topics might be added to this preliminary list or certain items deleted.

It was agreed to hold a meeting of all interested participants in France during 1977; this meeting is summarized below.

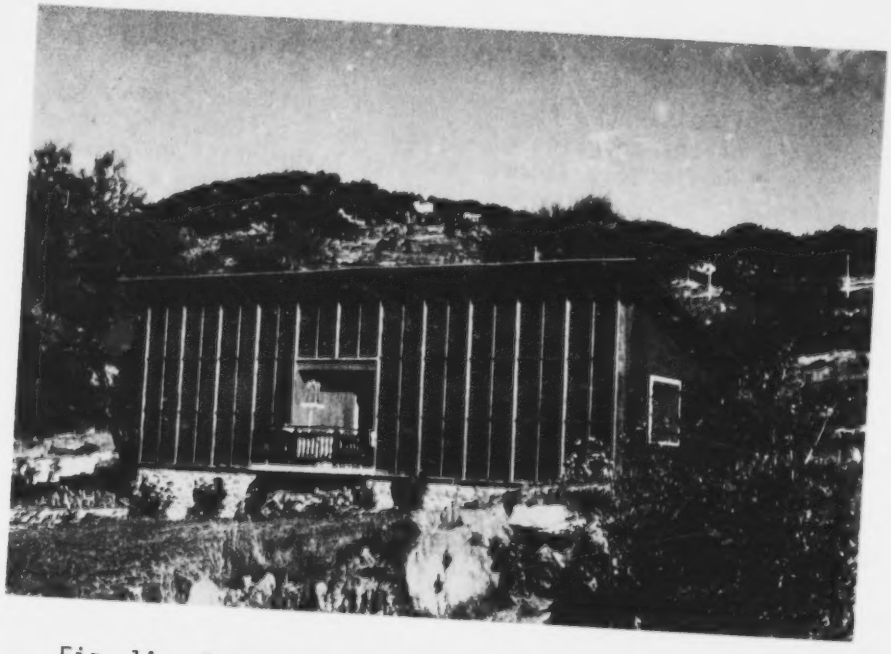

Fig. 14. This early passive solar house in Odeillo, France features one of the first Trombe-Michel wall installations.

1977 MEDITERRANEAN GROUP MEETING

The first meeting of the Mediterranean Applications Group was held at Nice, France during October 10-12, 1977. The working sessions took place at the Observatory of Nice. Following these a tour of local solar installations was conducted. More than thirty people attended, representing the following countries: France, Federal Republic of Germany, Iran, Israel, Italy, Monaco, Saudi Arabia, Spain, and the United States. The European Commission also participated. The program included fifteen presentations, grouped in three sessions.

Session 1

The first session consisted of the presentation of national solar activities, especially passive heating and cooling techniques, including demonstration projects. Pertinent programs of France, Italy, Saudi Arabia, Spain, the United States and the European Commission were presented A number of major documents were exchanged among the participants.

Session 2

This session, together with Session 1, produced discussions of many problems related to passive heating. Some of the main conclusions are summarized below:

- Solutions of multi-node thermal network equations have allowed the prediction of the behavior of storage wall systems (including Trombe walls) and roof-pond systems. Work is in progress on calculating the behavior of direct-gain houses, attached greenhouse structures, and thermosiphon-heated buildings.

- Temperature regulation in some of these systems may be a problem which will influence the acceptability of the sytems. In this respect, buildings equipped with thermosiphon collector/storage systems and forced air or water distribution systems may produce more uniform temperatures than the other type of systems.

- For thermal storage walls, water is best, and concrete is better than adobe. The interior air temperature variation decreases as the wall thickness increases, 40 cm of concrete being sufficient to produce acceptably small temperature fluctuations.

- Concrete walls containing water or latent-heat-of-fusion material are under development.

- The use of movable insulation is highly desirable to prevent heat loss at night in winter and to minimize heat gain during the day in summer. Much work is in progress to devise forms of movable insulation which will have sufficiently long lifetimes.

- Diffusion windows appear to be quite important for the successful operation of direct-gain systems.

- Initial indications are that theoretical computation will be possible soon for all types of passive structures and will allow the prediction of the thermal behavior of these structures in many different climates. However, much work in thermal modeling and computer code validation remains to be done.

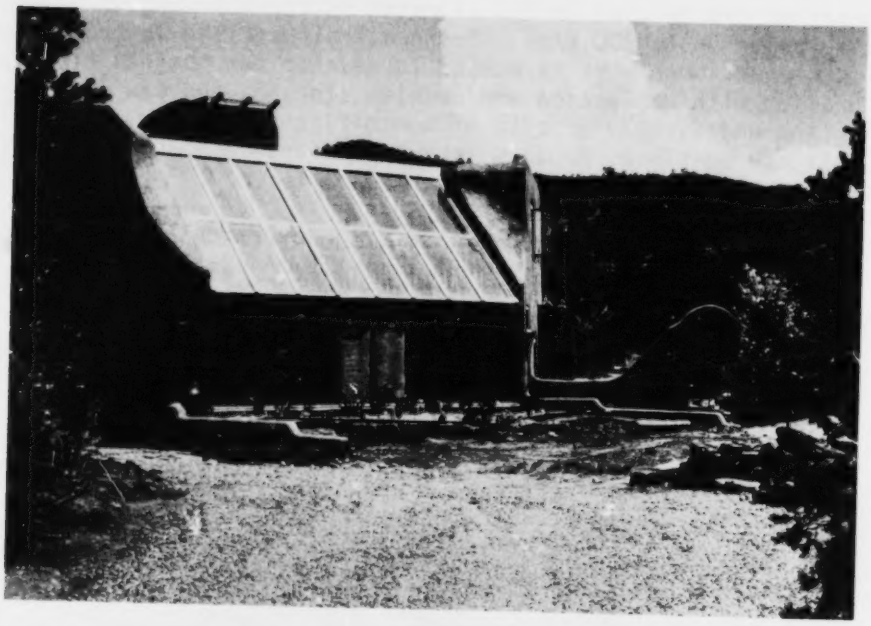

Fig. 15. Private residence in Santa Fe, New Mexico, USA, utilizing direct gain passive heating.

Session 3

This session mainly comprised a review of passive cooling including natural cooling by nocturnal radiation, cool night air, and evaporation. The use of solar-assisted heat pumps and absorption air conditioning was discussed briefly. Some tentative conclusions from the discussions are given:

- Many traditional houses in Europe, in Arab countries, and in Africa indicate the important influence of insulation and thermal inertia, and the desirability of designs which allow use of radiation, cool night air, or evaporation for cooling. Many designs and techniques have evolved over thousands of years. However, there is little quantification of these techniques and geometrics.

- Radiative cooling is well understood in that there is abundant knowledge of infrared radiation, its absorption by humidity in the air, and the use of appropriate selective surfaces. It appears that it should be possible to achieve a cooling power of 10 to 50 W/m^2 of radiator, depending on temperature differences and on convection losses. Practical components and their integration into buildings need further

study. It was stated that work is in progress on radiators which could perform during the day. System experimentation with radiators at various sites could be used to verify theoretical predictions and, therefore, to establish the effectiveness of radiative cooling in many climates.

- Evaporation can be used in dry climates in various ways to produce cooling power up to 300 W/m^2. Mathematical modeling is proceeding well; however, more work is needed to develop new methods of coupling evaporation with convection and/or with storage, and new ways of minimizing the undesirable effects of humidification of air. Several concepts are possible, ranging from primitive, inexpensive configurations to sophisticated, expensive ones.

- Economic analyses are needed to assess the practicality of radiative and evaporative cooling in various climatic zones.

- Active solar methods using traditional heat pumps and lithium bromide absorption air conditioners are also of interest. Again, a study of the economics of these cooling-machine systems is important.

Fig. 16. Passive solar residence in Los Alamos, New Mexico, USA, featuring a Trombe wall.

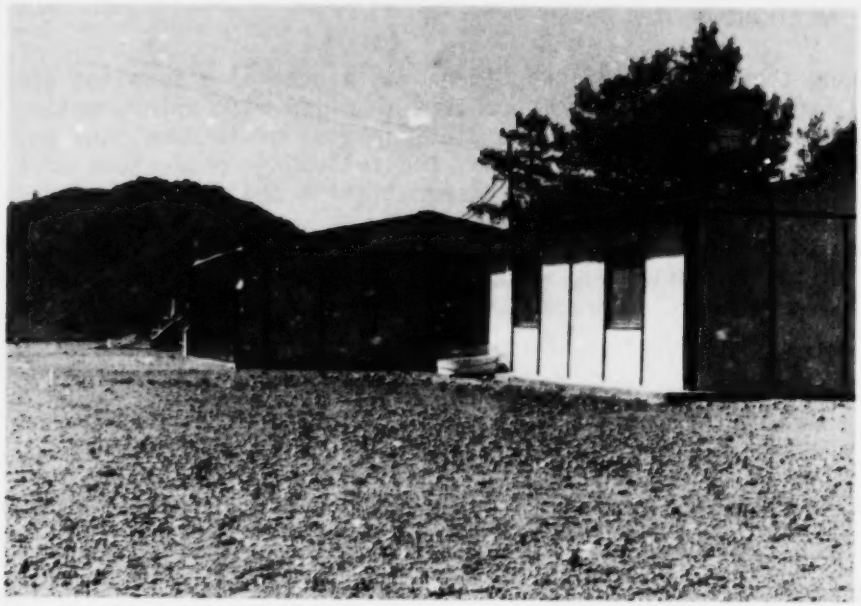

Fig. 17. Passive solar experimental house with Trombe-Michel wall (L) and reference house at Marmaris Solar Energy Research Center, Turkey.

Fig. 18. Phase change thermal mass wall and water thermal mass wall test cells, CNRS Solar Energy Laboratory, Nice, France.

GENERAL CONCLUSIONS

Following these presentations, there was a general discussion aimed at defining the main research and development problems involved with solar heating and cooling, desirable actions to be taken in the dissemination of information, and future co-operation. Based on these discussions, the following conclusions were reached as to the areas appropriate for continued cooperation in the Mediterranean Group:

- Concentrate on systems assessment. This implies the use of components like Trombe walls, radiators, evaporators, variable conductivity walls, greenhouses, storage, etc., but in the context of complete thermal systems.

- The CCMS System Performance Reporting Format is recommended for reports on any completed projects. The CCMS format should be modified to be appropriate for passive systems.

- Concentrate on passive systems, augmented by simple active solar systems or by standard back-up systems, for either heating or cooling.

- Continue the development of mathematical models to characterize solar systems so that the effectiveness of either heating or cooling can be predicted as functions of system variations or climatic variations.

- Conduct separate studies for new individual dwellings, new collective houses, retrofitting old houses and industrial buildings. These all appear to be worth experimentation, but in somewhat different perspectives.

- Extend existing or planned experiments on systems in two directions:

  (a) characterize acceptable room temperature variations and humidity from a comfort point of view, and

  (b) implement more physically meaningful instrumentation such as infrared mapping.

- Classify and quantify the various types of passive heating and cooling which abound in the countries surrounding the Mediterranean Sea, so that these techniques can be made available to all countries around the Mediterranean and to the rest of the world.

- The information exchange which occurred at the first meeting of the Mediterranean Applications Group was definitely worthwhile. It should be continued and improved, if possible.*

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* A second meeting has been scheduled for Fall 1978.

EXPECTED BENEFITS

The Mediterranean Applications Group has been the first international cooperative project to deal with alternative energy development in the Mediterranean region. It is clear that much progress can be made in developing appropriate passive and active solar systems and encouraging their widespread implementation as a result of bringing together representatives of the concerned countries and sharing information in technically-oriented workshop sessions.

Discussion of existing Mediterranean passive systems should indicate which ones show the most potential for use in other countries, and which are the most economic in construction and operation. These systems could be modelled by those countries possessing computer facilities for the benefit of countries not so endowed. In this way the diffusion of knowledge would expand and the applicability of various systems could be determined. This would be advantageous to countries immediately surrounding the Mediterranean, and to those in other parts of the world where the climate is similar.

PARTICIPANTS' ASSESSMENT OF THE PILOT STUDY

PARTICIPANTS' ASSESSMENT OF THE PILOT STUDY

Following the fourth Solar Energy Pilot Study Meeting in April 1978, the contact persons were requested by the Pilot Study Director to assess the effectiveness of this cooperative program. Responses were received from thirteen participating countries, and the comments are summarized below. Based on earlier formal and informal statements at various pilot study meetings, the responses appear to be quite representative of the participants' views.

REVIEW OF NATIONAL PROGRAMS

According to the evaluation survey, the review of national solar heating and cooling programs appeared to have made the broadest impact of any aspect of the pilot study. The successive status reports influenced the original shape, and subsequent expansion and modification, of many national programs. Specific comments received were:

- "Information obtained at Odeillo meeting permitted better definition of problems to be solved and directly influenced shape of our solar energy research projects."
- Helped first results of our program to be known abroad."
- "Gave us broader view of solar heating effort world-wide."
- "Helped accelerate our national program."
- "Enabled us to keep abreast of developments not yet reported in the literature."

ZERO ENERGY HOUSE GROUP

The Zero Energy House Group, comprised of seven countries with a specific interest in solar-assisted low-energy dwellings for northern latitude countries, appears to have served the needs of its members well. Enthusiasm for this subproject was high, as evidenced by expressed desire to continue this specialized cooperation. Respondents stated:

- "The Zero Energy House Group was highly efficient."
- "...very effective. Results of prime importance for understanding the thermodynamic behavior of modern housing technologies."
- "Found group to be most helpful and influential. Exchange of views with other designers significantly influenced design of our own low-energy experiments."
- "Interchange on innovative design and engineering concepts was of significant value."

MEDITERRANEAN APPLICATIONS GROUP

Expanding world-wide interest in passive heating and cooling points to increased need and desire for cooperation in this area. The Mediterranean Applications Group has held one meeting to date, and future meetings will permit collaboration in passive systems analysis and development and possible joint experimentation. A few comments on the Mediterranean Applications Group were:

- "Expect benefits from Mediterranean Group since there is growing interest in passive systems."
- "Opportunity for significant cooperation exists."
- "Group developing slowly. Hope participation will expand to other countries."

EXCHANGE OF SOLAR HEATING AND COOLING REPORTS

A large number of reports covering a wide variety of topics related to solar heating and cooling were exchanged by participating countries. In general this exchange was very useful and provided a picture of the broad range of activities underway in various countries, as well as specific technical information. A few respondents felt the impact of these reports was limited; this raises the question of whether dissemination or publicity of these reports was adequate. A sampling of remarks on this activity is presented:

- "Exchange of reports has been helpful in the preliminary work we are undertaking."
- "Exchange of solar heating and cooling reports has been of limited importance as solar heating research is limited. Those who have received reports do acknowledge their appreciation."
- "Difficult to assess the number of people reading these reports -- believed to be small."

SYSTEM REPORTING FORMAT AND SYSTEM PERFORMANCE REPORTS

The Solar Energy Pilot Study emphasized the reporting of system performance data and to this end developed the reporting format and encouraged exchange of system performance reports. Respondents viewed the availability of these reporting specifications and the objective of expanding the data base for system performance very favorably. Sample comments on this effort were:

- "Pilot Study increased awareness of importance of system studies. System Reporting Format (with some modification) has been used as national format."
- "Format unique -- accelerated transformation of performance measurement techniques from guesswork to a scientific level."

- "Played an important role on our format efforts within the IEA."
- "A lesson in discipline of reporting experimental results."
- "System Reporting Format is of great value."

ESTABLISHMENT OF CONTACTS IN SOLAR COMMUNITY

Although this subject was not mentioned on the assessment questionnaire, every respondent indicated that one of the most appreciated and important aspects of the pilot study was the opportunity to establish personal contact and close working ties with solar officials and researchers in many countries. This is pointed up by the following remarks:

- "Pilot study established channels of communication."
- "Opportunity for contact with responsible officials and technical experts helpful."
- "Has been of great interest to meet the specialists in the field and establish personal contacts."
- "International contacts on a personal basis always invaluable."

CCMS/ISES TECHNICAL CONFERENCE

This conference was an attempt to give wide exposure to the CCMS Reporting Format and provide a public forum for the presentation of much-needed performance data. While this conference was not singled out on the list of activities to consider in the evaluation -- and as a result only a few relevant comments were received -- the favorable comments on the value of the format and emphasis on system performance data can be considered applicable to the conference as well. Statements on the technical conference were:

- "One of the most important conferences on solar heating systems held so far."
- "Additional conferences of this kind needed to disseminate performance results."

LIMITATIONS

A few respondents indicated that the scope of the pilot study did not directly address the needs or thrust of their national solar research and development programs. The opinion was also expressed that the pilot study would have been more effective if cooperative development or testing of hardware or systems had been undertaken. Representative comments on the limitations of the pilot study or recommendations for improved effectiveness were:

- "Would have been desirable to address specific technical problems not yet addressed at international level."

- "Study would have been more efficient if full time people were involved in international relations and diffusion of information, but this is not possible."
- "Collector and system performance evaluation would have made pilot study more effective."
- "Help avoid duplication of efforts by more detailed information on what research has given good or disappointing results."
- "Pilot Study not directly useful because of little activity in solar heating and cooling of buildings."

GENERAL OBSERVATIONS

It is obviously difficult for an international project to have an equally positive effect on all participating countries. The member countries were and still are at different stages of solar development. Climate and building needs also vary, and consequently appropriate applications and technologies differ from country to country.

Within its pre-determined scope (of exchange of information on national solar heating and cooling programs and experiments), the Pilot Study attempted to provide tools (such as the format), and opportunities for interchange and sharing of information among experts. To some extent, the benefits received from the pilot study can be judged to have been a function of the level of participation of the individual countries. In the large number of instances where countries participated in most or all of the activities and meetings, they seemed to feel the cooperation had benefited their own solar program. Where distance, different emphasis, limited funding, etc. impeded full participation, the pilot study was of less value. While the impact of the Solar Energy Pilot Study has varied, the assessment of the participants is favorable and the cooperation successfully achieved its objective.

APPENDIX

APPENDIX A

MEMORANDUM OF UNDERSTANDING
CONCERNING COOPERATIVE INFORMATION EXCHANGE RELATING TO THE DEVELOPMENT OF SOLAR HEATING AND COOLING SYSTEMS IN BUILDINGS

The agencies which have signed the Memorandum of Understanding,

Recognizing that there are within the territories of the governments of the parties to the Memorandum of Understanding, governmental and industrially-sponsored programs which collectively form a broad-based attack on the challenging energy problems facing our societies, and

Believing that international cooperation in the field of solar energy for heating and cooling processes in buildings will prove fruitful for all concerned, and desiring to undertake a comprehensive exchange of knowledge gained about the design, the technical characteristics, and the performance of solar energy systems and subsystems developed in the course of conducting and monitoring projects related to solar heating and cooling in buildings,

Agree as follows:

1. The aim of this Memorandum of Understanding is to encourage the cost-effective and practical application of solar energy to heating and cooling in residential, commercial, industrial, agricultural and public buildings. This aim shall be accomplished through the exchange of information related to research programs and experiments and by developing an agreed format for reporting performance characteristics of solar heating and cooling systems in such applications. Information respecting the performance of the major subsystems shall be included in the exchange, together with information respecting whole systems experiments relating to the effectiveness of solar energy in heating and cooling processes in buildings. Information exchange respecting both subsystems and whole systems shall, to the maximum feasible extent, include data relating the experiment to the thermal requirements and climatological and social conditions involved.

2. Each signatory of the Memorandum of Understanding shall appoint a representative through whom the information specified above shall be exchanged. Each signatory shall send to all other signatories special reports -- prepared in an agreed format -- on projects under the sponsorship or coordination, or with the participation of the signatory, at significant stages of work on solar heating and cooling processes in buildings, and of relevant and publically available reports concerned in whole or in part with the subject matter of the Memorandum of Understanding. Copies of (a) the special reports in the agreed format, (b) of the full reports upon reasonable request, and (c) of additional material of general interest shall be sent expeditiously to the representative designated by each

signatory. The signatories agree also to the maximum feasible extent to dispatch to the other signatories relevant information published by other governmental institutions, universities, private corporations and groups, and technical societies in their country.

3. Additionally, the parties will participate in meetings, which are expected to be held at least annually, for the review of research and development programs and for discussions and exchange of information and ideas for further research.

4. Participation in the agreements established by this Memorandum of Understanding and annexes is subject to the laws of the respective countries. This includes laws respecting the protection of proprietary data and rights in intellectual property, including patents and copyright. All signatories agree to respect any such rights as may be established in accordance with the laws of other signatories as may relate to this Memorandum of Understanding. Participation is further subject to the availability of appropriations to each signatory, as such availability may be determined in accordance with the legal processes of the government of the individual country.

5. The signatories shall exercise their best efforts hereunder to ensure that all data in the subject area of this Memorandum of Understanding can be exchanged and will not be subject to claims for confidential treatment of any kind. Where, however, a private contractor or grantee maintains such claims despite the efforts to avoid such claims required herein, the signatories shall encourage such contractors or grantees to exchange data subject to such claims with other signatories to this Memorandum of Understanding, through special agreements or otherwise.

6. It is contemplated that a number of detailed procedures will be developed for cooperative efforts between agencies and will be incorporated as annexes to the original of this Memorandum of Understanding. When two or more signatories to this Memorandum of Understanding develop more specific relationships on subprograms or projects within the field of this Memorandum of Understanding, details of any agreement or arrangement between them may be annexed to the original of this Memorandum of Understanding.

7. Any signatory may terminate its participation under this Memorandum of Understanding by written notification to all other signatories. Such termination shall be effective 60 days from the date of the notification.

8. The original of this Memorandum of Understanding shall be deposited with the Department of State of the United States of America, which shall transmit two copies of the Memorandum of Understanding to each agency which notifies its intention to become a party hereto. Both copies shall be signed and dated on behalf of the agency and one copy shall be returned to the Department of State, which shall inform all agencies of signatures.

9. This Memorandum of Understanding shall enter into force on July 1, 1975, with respect to those signatories which have signed the Memorandum of Understanding on or before that date. With respect to those which sign subsequently, it shall enter into force on the date of signature.

APPENDIX B

PARTICIPATING COUNTRIES AND CONTACT PERSONS

MOU SIGNATORIES

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APPENDIX C

PILOT STUDY MEETINGS

The Solar Energy Pilot Study convened four meetings (aside from meetings of the Zero Energy House and Mediterranean Application Groups). The initial meeting in Odeillo in October 1974 was significant in that it established the general pattern for subsequent meetings, and the activities of the pilot study itself. This was also the occasion of the first exchange of reports on national solar heating and cooling programs and the formation of the Zero Energy House Group.

The subsequent meetings generally consisted of:

- A review of activities and accomplishments of the past year
- Presentations on the status of national solar heating and cooling programs
- Discussion of the CCMS System Reporting Format and future system performance reports
- Reports of the Zero Energy House Group and Mediterranean Applications Group
- Discussion on future activities.

A major highlight of the August 1975 meeting in Palo Alto, California was the adoption of the CCMS System Reporting Format and the commitment to preparation of performance reports utilizing that format.

The Mediterranean Applications Group was formally established at the Copenhagen Meeting in September 1976 and reports were presented on the initial applications of System Reporting Format.

During the final Solar Energy Pilot Study meeting, held in April 1978 at Düsseldorf, Germany, the participants formulated recommendations for follow-up action to continue multilateral cooperation in solar heating and cooling of buildings.

A list of participants for the four meetings follows in this appendix.

FIRST SOLAR ENERGY PILOT STUDY MEETING

Odeillo, France
October 1-4, 1974

COUNTRY	PARTICIPANTS	AFFILIATION
AUSTRALIA	Mr. R. Morse	C.S.I.R.O.
BELGIUM	Prof. A. Pilatte	Faculte Polytechnique de Mons
BRAZIL	Mr. Junqueira	Brazilian Embassy, Paris
CANADA	Dr. D. G. Stephenson	National Research Council
DENMARK	Mr. T. Esbensen	Technical University of Denmark
	Prof. V. Korsgaard	Technical University of Denmark
FEDERAL REPUBLIC OF GERMANY	Dr. H. Birnbreier	Brown, Boveri and Cie
	Mr. F. Friedrich	KFA, Jülich
	Mr. P. Goericke	RWE
	Dr. H. Hoerster	Philips Research Laboratory
	Dr. H. Klein	Ministerium Für Forschung und Technologie
	Prof. G. Lehner	Universität Stuttgart
	Dr. L. Rouvel	Institut fuer Energiewirtschaft und Kraftwerkstechnik
	Dr. K. P. Schubert	Dornier System
	Dr. H. Stehr	Siemens A.G.
	Dr. P. Zahn	MBB
FRANCE	Ms. Ballay	Delegue Scientifique a l'ANVAR
	Dr. J. Deflandre	CNRS-Odeillo
	Dr. M. Foex	CNRS-Toulouse
	Prof. J. Lagasse	Centre National d'Etudes Spatiales
	Mr. W. Palz	CNRS-Marseille
	Dr. G. Peri	CNRS-Odeillo
	Mr. J. F. Robert	CNRS-Odeillo
	Dr. F. Trombe	
GREAT BRITAIN	Mr. R. G. Courtney	Building Research Station
	Mr. P. G. O'Neill	Department of the Environment
GREECE	Mr. P. Spanides	Nuclear Research Center Democritos
	Prof. A. Spyridonos	North-East London Polytechnic
	Mr. C. Stambolis	
ISRAEL	Dr. H. Tabor	The Scientific Research Foundation
ITALY	Prof. G. Francia	Universita Genova
	Prof. G. Zorzoli	CISE

JAMAICA	Ms. B. King	L'Ambassade de la Jamaique, Paris
LUXEMBOURG	Mr. J. Schleich	Ministere de l'Energie
NATO	Dr. F. Kovach	NATO
	Mr. Spielman	Division des Affaires Scientifiques
THE NETHERLANDS	Mr. J. A. Knobbout	Central Technical Institute TNO
	Mr. C. Den Ouden	Applied Physics Laboratory TNO
	Prof. C. W. Van Koppen	Eindhoven University of Technology
	Prof. A. C. Verhoeven	Delft University of Technology
SAUDI ARABIA	Mr. F. Kabbani	Directorate General of Mineral Resources
TURKEY	M. T. Turgay	
UNITED STATES	Mr. J. M. Coogan	U. S. Embassy, Paris
	Mr. R. H. Fields	National Science Foundation
	Mr. F. A. Harris	Environmental Protection Agency
	Dr. F. Morse	University of Maryland
	Mr. C. Sanders	NATO

SECOND SOLAR ENERGY PILOT STUDY MEETING

Palo Alto, California USA
August 4-6, 1975

COUNTRY	PARTICIPANTS	AFFILIATION
AUSTRALIA	Mr. R. Morse	C.S.I.R.O.
	Dr. D. Proctor	C.S.I.R.O.
THE BAHAMAS	Mr. P. Bethel	Bahamas Electric Corporation
BELGIUM	Prof. G. Labeau	Faculte Polytechnique de Mons
BRAZIL	Dr. A. Orlando	Universidade Estadual de Campinas
CANADA	Mr. J. Sasaki	National Research Council
DENMARK	Mr. T. Esbensen	Technical University of Denmark
	Mr. S. Svendsen	Technical University of Denmark
EL SALVADOR	Mr. E. Casamiquela	Comision Ejecutiva Hidroelectrica del Rio Lempa
FEDERAL REPUBLIC OF GERMANY	Dipl. Ing F. Friedrich	KFA, Jülich
	Dr. F. Gross	Brown, Boveri and Cie AG
	Dr. H. Horster	Philips Research Laboratory
	Dr. R. Kersten	Philips Research Laboratory
	Prof. G. Lehner	University of Stuttgart
	Dr. K. Schubert	Dornier-System
	Dr. Ing. U. Sprengel	DFVLR
	Dr. C. Van Zwet	Philips Research Laboratory
FRANCE	Dr. J. Deflandre	Deleque Scientifique a l'ANVAR
	Mr. J. F. Robert	CNRS-Odeillo
GREECE	Prof. A. Deliyannis	Greek Atomic Energy Commission
	Dr. E. Deliyannis	Greek Atomic Energy Commission
ISRAEL	Dr. H. Tabor	The Scientific Research Foundation
ITALY	Prof. M. Silvestri	CNR
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THE NETHERLANDS	Mr. C. den Ouden	Institute of Applied Physics TNO-TH
	Dr. M. van der Leij	Delft University of Technology
	Prof. C. van Koppen	Eindhoven University of Technology

NEW ZEALAND	Mr. M. Hope	New Zealand Consul General, San Francisco
THE PHILIPPINES	Mr. B. Domingo	Philippine Consulate General, San Francisco
PORTUGAL	Mr. A. Costa	Dir. Geral dos Combustiveis
SAUDI ARABIA	Dr. F. Kabbani	Directorate General of Mineral Resources
	Dr. M. Kettani	University of Petroleum and Minerals
SPAIN	Dr. J. Fernandez-Sintes	INTA
	Dr. G. Yanez	
SWEDEN	Mr. L. Engström	Uhlin and Malm, Architects
	Mr. J. Ostrom	Hugo Theorells Ingeniorsbyra AB
UNITED KINGDOM	Mr. R. Courtney	Building Research Station
UNESCO	Mr. C. Stambolis	North-East London Polytechnic
UNITED STATES	Ms. E. Campbell	Department of State
	Mr. R. Fields	ERDA
	Mr. F. Harris	Environmental Protection Agency
	Mr. W. Matheny	U.S. Technical Information Center
	Prof. F. Morse	University of Maryland
	Dr. I. Rose	University of Maryland

THIRD SOLAR ENERGY PILOT STUDY MEETING

Copenhagen, Denmark
September 13-15, 1976

COUNTRY	PARTICIPANTS	AFFILIATION
AUSTRALIA	Mr. R. N. Morse	C.S.I.R.O
BELGIUM	Prof. A. Pilatte	Faculte Polytechnique de Mons
CANADA	Mr. J. R. Sasaki	National Research Council
DENMARK	Mr. T. V. Esbensen	Technical University of Denmark
	Mr. K. Hallgreen	Danfoss
	Prof. V. Korsgaard	Technical University of Denmark
	Mr. K. Kraegpøth	Technical University of Denmark
	Mr. J. Lemming	Technical University of Denmark
	Mr. O. Smith-Hansen	Danish Ministry of Housing
	Mr. S. Svendsen	Technical University of Denmark
FEDERAL REPUBLIC OF GERMANY	Mr. H. Birnbreier	Brown, Boveri and Cie
	Mr. F. J$_n$ Friedrich	KFA, Jülich
	Dr. H. Horster	Philips Research Laboratory
	Prof. G. Lehner	University of Stuttgart
	Dr. K. Schubert	Dornier System
	Dr. P. Zahn	Messerschmitt-Boelkow-Blohm GmbH
	Dr. M. Schneller	German Delegation to NATO
FRANCE	Mr. J.-P. Marie	Ministere de l'Equipement
	Mr. J. Pheline	Delegation aux Energie Nouvelles
	Mr. J.-F. Robert	CNRS-Odeillo
	Dr. M. Rodot	CNRS-Paris
	Mr. M. Schneider	CNRS-Nice
GREECE	Prof. A. Deliyannis	Greek Atomic Energy Commission
	Dr. E. Deliyannis	Greek Atomic Energy Commission
HAITI	Mr. A. Celestin	Electricite D'Haiti
IRAN	Mr. M. Ameri	Ministry of Energy of Iran
	Mr. S. R. Larijani	Ministry of Energy of Iran
	Prof. A. Sabzevari	Pahlavi University
ISRAEL	Dr. H. Tabor	The Scientific Research Foundation
LUXEMBOURG	Mr. J. Removille	LUXATOM
	Mr. J. L. Schleich	Ministre de l'Energie

MEXICO	M. X. Garzon-Cardenas	Consejo Nacional de Ciencia y Tecnologia
MONACO	Mr. J. H. Millar	P.D.G. Flextube S.A.
THE NETHERLANDS	Mr. W. F. Heshuysen	Netherlands Energy Research Foundation
	Prof. C. van Koppen	Eindhoven University of Technology
	Mr. C. den Ouden	Institute of Applied Physics TNO
SAUDI ARABIA	Mr. K. Nahdi	Ministry of Petroleum and Mineral Resources
	Mr. Y. Nassif	Saline Water Conversion Corp.
	Dr. F. A. Somait	University of Petroleum and Minerals
SPAIN	Dr. J. Fernandez-Sintes	INTA
SWEDEN	Mr. L. Engström	Uhlin and Malm, Architects
	Mr. E. Öfverholm	Royal Institute of Technology
TURKEY	Mr. M. Babayigit	Mineral Research Institut
	Mr. A. Mutdogan	Ministry of Energy and Natural Resources
	Mr. C. Pala	Ministry of Energy and Natural Resources
UNITED STATES	Dr. R. W. Allen	University of Maryland
	Mr. F. A. Harris	Environmental Protection Agency
	Dr. F. H. Morse	ERDA
	Mr. T. Savage	U.S. State Department
	Ms. S. Blum	University of Maryland
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	Mr. D. van Asselt	Joint Research Center EURATOM
NATO	Mr. L. Klette	NATO
	Mr. J. G. Sampas	NATO

FOURTH SOLAR ENERGY PILOT STUDY MEETING

Düsseldorf, Germany
April 17-18, 1978

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	Prof. V. Korsgaard	Technical University of Denmark
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	Mr. W. Martin	European Commission
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APPENDIX D

CCMS SYSTEM PERFORMANCE REPORTING FORMAT

The objective of this system reporting format is to ensure that sufficient information is provided to enable the reader to make his own assessment of the performance of a solar heating and/or cooling system and to relate that performance, which was carried out in one particular climate and economic environment, to a different climate and economic environment.

All details of the format are to be followed as completely as possible. In addition, information on all related back-up reports is requested, including specific instructions on how they may be obtained.

FORMAT FOR REPORTING SYSTEM PERFORMANCE

I. GENERAL DESCRIPTION OF SYSTEM PROJECT AND ENVIRONMENT

A. Objective of Project

- Brief description of objective and strategy of project, including duration and major milestones.

B. Description of the Environment

1. Climate

- Brief description of type of climate, according to the Trewartha* worldwide classification system.
- Annual rain and snow fall (mm per year).
- Description of typical sky conditions relative to "clear sky"; either average daily sunshine hours, number of sunshine hours per year, the percentage of maximum possible sunshine hours or annual average cloud cover fraction may be used.

2. Location

- Latitude, longitude, and altitude (in m) of system.
- Description of the configuration of the location and distance from solar or wind obstructions or significant geographic features (seas, mountains, etc., in km).
- Comment on air quality, i.e . dust precipitation.

*G.T. Trewartha, An Introduction to Climate (McGraw Hill: New York, 1968).

3. Solar Radiation

- Mean monthly global (total) and, if relevant, diffuse isolation on a surface whose orientation is described. The number of years over which this mean is defined should be specified, as well as the time intervals of the data.
- Description of the measurement equipment.

4. Ambient Temperatures

- Mean monthly dry and wet bulb temperatures (relative humidity may be used in place of wet bulb temperature).
- Number and basis of degree-days of location.
- Description of the measurement equipment.

5. Wind

- Average monthly wind speed and prevailing direction (0-360^{o} from North towards East).
- Description of measuring equipment.

C. Description of System

1. Qualitative Description

- Description of the entire system, as well as the solar system, by narrative, photographs, or drawings.

2. Quantitative Description

- Description of the system performance characteristics, including schematic drawings.
- Orientation* and inclination+ of collectors.
- Control system description, performance characteristics, and location within the system. The operating modes should be described.
- Measurement system description, performance characteristics (such as precision and repeatability), and location within the system.

II. SYSTEM THERMAL PERFORMANCE -- The information in sections A, B, C and D is essential and therefore should be as complete as possible.

A. Daily, Monthly and Annual Values** of the Mean Daily (Tabular or Graphical Form)

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* Angle between the projection of the sun's rays, at solar noon, on the horizontal plane and the projection of the normal to the collector on the horizontal plane.

\+ Angle between horizontal and normal to collector.

** The monthly value of the mean daily quantities is the most important of the three. Daily values may be provided as optional information.

- Total energy required (thermal load, heating or cooling, on system).
- Supplemental energy required (amount, kind, and purpose).
- Solar energy incident on collectors.++
- Solar energy collected
- Solar energy used.

The criteria for the use of supplemental energy must be described.

B. Record of the Quality of Thermal Performance of the System (e.g., departure from the design temperature over reporting period).

C. Solar Contribution to Energy Requirements -- daily, monthly and annual values* of percent solar contribution to the energy requirements.

D. Monthly and Annual Energy or Fuel Savings -- based on primary fuel (state type).

E. Energy and Mass Balances

This information is of secondary importance in that it is this information that is used to determine quantities reported in IIA. If possible, it is suggested (optional) that a typical day be used to show:

- Significant energy flow rates -- additions and losses.
- Significant mass flow rates -- additions and losses.
- Temperature and pressure at critical locations.
- Temperature drop and pressure drop across major components.

III. SYSTEM ECONOMIC ANALYSIS

The following costs and factors should relate to the solar portion of the project but could also be specified for the entire project.

A. Total Cost of the Solar Portion of the System -- with a specific definition made of the interface between the solar and non-solar portions of the system. If possible separate design costs from component and installation costs.

B. Labor Costs -- in man-hours and in local currency, for the installation of the system.

C. Materials Costs -- in weight or volume as appropriate and in local currency.

** It is suggested that this be based on (at least) hourly values of the global (and/or direct, if appropriate) insolation measured in the plane of the collectors. If the global insolation is only measured on a horizontal surface, it should be so provided and the method used to determine the amount incident on the plane of the collectors should be described.

* The monthly value of the meandaily quantities is the most important of the three. Daily values may be provided as optional information.

D. Operational Costs -- including supplemental energy costs, in local currency.

Since operational costs depend on the assumed system lifetime, it is suggested that the assumed system lifetime be stated along with the depreciation rate.

E. Local Economic Factors -- such as inflation, interest rates and amortization periods.

F. Expected Selling Price or Costs -- assuming that the system or solar components are mass produced.

G. Maintenance Frequency and Costs -- in hours and material.

H. User Reactions and Comments.

IV. CONCLUSIONS

FORMAT FOR REPORTING SUBSYSTEM PERFORMANCE

A. SOLAR COLLECTORS

1. Description of Physical Configuration

- Description of solar collectors by narrative, photographs, and drawings, including collector materials, designs, dimension, and construction.

2. Thermal Performance Characteristics

- Collector efficiency curves (efficiency as a function of average fluid temperature or inlet coolant temperature, ambient air temperature, solar radiation normal to the collector, and wind speed) or equivalent collector performance indication (such as heat production) for several days that typify the full range of operation of the system.
- Pressure drop through collectors.
- Optical efficiency vs. incident angle, daily, monthly, and annual optical efficiency.*
- Thermal loss coefficient as a function of the difference between the ambient and the mean plate temperature, for known wind speeds.*

3. Lifetime Performance Characteristics

- Corrosion
- Leakage
- Hot spots
- Breakage

*Optional information to be included if known.

- Stability of collector working fluid

B. HEAT TRANSFER SUB-SYSTEM

1. Description of Physical Configuration

- Description of heat transfer sub-system by narrative, photographs, and drawings. Specify construction materials and working fluids.

2. Thermal Performance Characteristics*

- Inlet and outlet temperatures on both sides of exchanger.
- Inlet and outlet pressures on both sides of exchanger.
- Mass flow rates on both sides of exchanger.
- Pumping power.

C. THERMAL ENERGY STORAGE SUB-SYSTEM

1. Description of Physical Configuration

- Description of thermal energy storage sub-system by narrative, photographs, and drawings.
- Specify construction materials and working fluids, location within system, insulation details (material and construction), mass and volume of storage sub-system, storage duration and/or energy stored at same temperature.

2. Thermal Performance Characteristics*

- Mean temperature, hourly and daily, of the immediate surroundings.
- Thermal loss or gain, hourly and daily.
- Storage capacity.
- Inlet and outlet temperatures and pressures.
- Flow rates and pumping power.
- If phase change materials are used, specify compound and thermal characteristics.

D. AIR-CONDITIONING SUB-SYSTEM

1. Description of Physical Configuration

- Description of air-conditioning unit by narrative, photographs, and drawings.

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* Optional Information to be included if known.

• This information is of secondary importance in that it is this information that is used to determine the quantities reported in II A. If possible, it is suggested (optional) that a typical day be used to show:
  - Significant energy flow rates -- additions and losses.
  - Significant mass flow rates -- additions and losses.
  - Temperature and pressure at critical locations.
  - Temperature drop and pressure drop across major components.

- Type of sub-system -- heat pump, absorption, passive, etc.
- Heat rejection method.

2. Thermal Performance Characteristics

- Capacity at design inlet (to air-conditioning unit) temperature.**
- Capacity+ and coefficient of performance COP curves (inlet temperature as variable).**
- Sensitivity of the capacity and COP to variations in inlet temperature, evaporation temperature, wet and dry bulb temperature.

The International System (S.I.) will be used exclusively++ with the following recommendations:

Pressure	- given in Kpa
Temperature	- ^{o}C
Energy	- MJ and/or Kwh
Solar Flow Rate	- Kw, w
Solar Radiation	- the intensity will be given in W/m^2, the hourly, daily, monthly or annual totals will be given in MJ/m^2 day averaged over a day, month, or year.
Wind Speed	- m/sec
Mass Flow Rate	- l/sec or kg/sec

** Condenser, absorber and evaporator temperatures should be stated.
* Including the ratio of sensible to latent heat removal.
++ According to the resolutions of the Conference Generale des Poids et Mesures, 1960.

CCMS FORMAT SUMMARY OUTLINE

The objective of the Format Summary Outline is to enable an author to prepare a summary of a system performance report which provides the reader with information sufficient to enable him to understand the nature of the project, the principal features of the environment, building, and the solar heating and/or cooling system, as well as to give him a perspective on the month-by-month thermal performance of the system, and major economic factors. Details of system controls, operating modes, daily performance and economic projections are to be provided in the complete system performance report, prepared in accordance with the "CCMS System Reporting Format." Quantitative information is to be reported in the International System of Units.

I. GENERAL DESCRIPTION

I.A. Project: Name, Location, Objective(s), Brief Description*
(Approximately 100 words)

I.B. Environment

- Latitude, Longitude and altitude of project
- Table of monthly averages of:

  (1) Percent of sunshine or cloud cover fraction

  (2) Mean daily solar radiation on surface of specified orientation

  (3) Ambient temperature, dry bulb and wet bulb

  (4) Heating degree days and cooling degree days

  (5) Wind velocity

Table:

Month	(1)	(2)	(3)	(4)	(5)

I.C. System

- Highlights of Building and System Features (Approximately 50 words).

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* Note I.C., System Highlights

- One or two system diagrams.
- Major operating modes (approximately 50 words).
- Building Characteristics
    - Type of occupancy or use
    - Floor area heated and type of heating system
    - Design heat load per unit design temperature difference
    - Floor area cooled and type of cooling system
    - Design cooling load per unit design temperature difference
- Collector Characteristics
    - Typify in terms of applicable factors such as number of glazings, concentrator type, evacuation, selective surface, fluid type, reflective components
    - Freeze protection method
    - Normal maximum outlet temperature
    - Efficiency parameters $F_R \tau\alpha$ and loss coefficient
    - Location with respect to building
    - Orientation of collector plane or tracking axis orientation
- Hot-Side Storage Characteristics
    - Typify in terms of applicable items such as water, rock, phase-change material. Containment material. Heat exchange method.
    - Volume, weight, and normal maximum temperature
    - Location with respect to building
    - Gross heat capacity per degree or per phase change
    - Loss coefficient
- Cold-Side Characteristics
    - Typify in terms of applicable items such as water, rock, phase-change material. Containment material. Heat exchange method.
    - Volume, weight, and normal minimum temperature

- Location with respect to building
- Gross heat capacity per degree or per phase change
- Loss coefficient

- Auxiliary Energy Supply Characteristics
  - Type
  - Capacity and efficiency
- Cooling Unit Characteristics
  - Type
  - Design Point
  - Capacity and COP at design point
  - Off-design operating range
- Service Hot Water System Characteristics
  - Normal load
  - Solar preheat or other arrangement. Heat exchanger type.
  - Tank sizes

II. SYSTEM THERMAL PERFORMANCE SUMMARY

II.A. Table of Monthly and Annual Averages of Mean Daily Energy Quantities, by Column Number

(1) Solar energy incident on plane of collectors

(2) Solar energy to hot-side storage

(3) Useful energy from hot-side storage

(4) Solar energy to space heating

(5) Auxiliary energy to space heating

(6) Heat recovery subsystem heat to space heating

(7) Solar energy to service hot water

(8) Auxiliary energy to service hot water

(9) Heat recovery subsystem heat to service hot water

(10) Solar energy to cooling

(11) Auxiliary energy to cooling

(12) Energy to cold-side storage

(13) Useful energy from cold-side storage

(14) Percent of heating and service hot water provided by solar energy

(15) Percent of cooling provided by solar energy

(16) Percent of heating and cooling provided by solar energy

(17) Electric energy to pumps and fans

(18) Number of days solar and data system were operating

Tabular format:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Month . . . Annual									

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Month . . . Annual									

II.B. Departure from Desired Building Space Conditions

II.C. Degree to which Energy and Mass Balances were Achieved

II.D. Fuel Savings - Primary fuel type and monthly savings

III. SYSTEM ECONOMIC DATA

Costs: Labor, material and total operating cost including supplemental energy.

IV. MAJOR CONCLUSIONS - Approximately 100 words

APPENDIX E

REPORTS EXCHANGED BY PARTICIPATING COUNTRIES

AUSTRALIA

Report on the Status of Solar Energy Utilization in Australia for Industrial, Commerical and Domestic Purposes. Prepared by R.N. Morse, P.I. Cooper, and D. Proctor, Report No. 74/1, July 1974.

Progress Report on the Performance of Three Australian Solar Hot Water Systems By H. Salt, SES Report NO. 8, September 1976.

Solar Heating as a Major Source of Energy for Australia, By. R.N. Morse. Paper presented at The Tenth World Energy Conference, Istanbul, Turkey, September 19-23, 1977.

Final Report on the Performance of Three Australian Solar Hot Water Systems. By H. Salt. SES Report No. 9. July 1977.

CANADA

Special Format Report (Interim) on the Provident Solar House, Toronto, Ontario.

Special Format Report (Interim) on the Mississauga Solar House, Toronto, Ontario.

Technical and Economic Feasibility of Solar Energy Heating in Canada. K.G.T. Hollands, J.F. Orgill, Waterloo Research Institute, University of Waterloo, Waterloo, Ontario; Yearly Report. Project 4107, April 1976.

User's Manual for WATSUN - A Solar Heating Simulation and Economic Evaluation Program. J.F. Orgill, K.G.T. Hollands, Waterloo Research Institute, University of Waterloo, Waterloo, Ontario, April 1976.

Task Force on Energy Research and Development - Exploit Renewable Energy Resources: Solar Energy. R&D Program Outline, March, 1975.

Continuation Study of Potential for Solar Heating in Canada, #77-02, Hollands and Orgill, University of Waterloo, August 1977.

Turn on the Sun, Ministry of Energy of Ontario, September, 1977.

Potential for Solar Heating in Canada, K.G.T. Hollands and J.F. Orgill, University of Waterloo, #77-01, February 1977.

DENMARK

Solenergi-dagen, Juni 1976. Laboratory for Thermal Energy, Technical University of Denmark, June 1976.

The Zero Energy House, a One-Family, One-Storied House Designed and Constructed with Special Reference to Energy Conservation. By Van Korsgaard and Torben Esbensen. Meddelelse Nr. 31. September 1974.

Zero Energy House, Korsgaard et al, Technical University of Denmark, 1976.

FEDERAL REPUBLIC OF GERMANY

Energy Research and Development Program of the Federal Republic of Germany, Annual Report, 1975.

Proposal for a Cost and Systems Study of the Philips Solar House. By R. Bruno (Philips Forschungslaboratorium Aachen GmBH).

Nutzungsmoglichkeit fur Sonnenenergie in Mitteleurope Studie. Brown, Boveri & Cie AG, Zentrales Forschungslabor, Heidelberg, December 1973.

Guidelines and Directions for Determining the Feasibility of Utilizing Solar Collectors: Efficiency Tests of Solar Collectors, Arbeitsgemeinschaft Solarenergie E.V., September 1976.

Energy R&D Program of the Federal Republic of Germany, Project Management for Energy Research-KFA Jülich, Annual Report 1976.

Energy Research and Energy Technologies Program, 1977-1980, Ministry of Research and Technology.

Programm Technologien zur Nutzung der Sonnenenergie, 1977-1980, Ministry of Research and Technology.

Forschung Aktuell: Sonnenenergie , 1976 and Forschung Aktuell: Sonnenenergie II, 1977. Hans Matthofer, Editor.

FRANCE

Programme Interdisciplinaire de Recherche pour le Developpement de l'Energie Solaire, 1976.

Experimentation des maisons solaires a chauffage solaire d'Odeillo. F. Trombe, J.F. Robert, M. Cabanat, B. Sesolis, C.N.R.S. - Laboratoire de l'Energie Solaire. (Special Format Report)

Les capteurs solaires a eau, mesure et extrapolation. B. Devin, C.E.A. - Service d'Etudes Energetiques.

FRANCE
Continued

Station autonome de saisie et de concentration de donnees heliometriques. J. Colomes, M. Gorgeou, C.E.A. - Service d'Etudes Energetiques.

Methodologie des projects de chauffage solaire. Ph. Chouard, E.D.F. (Electricite de France) - Les Renardieres.

Essai d'un capteur solaire de marque .... en insolation naturelle. Ph. Chouard, E.D.F. (Electricite de France) - Les Renardieres.

Collection de documents decrivant des programmes de recherche francais touchant l'energie solaire.

Energies Nouvelles: l'energie Solaire (document publie par la Delegation aux Energies Nouvelles).

GREECE

Reflecting Horizontal Solar Collector. Greek Atomic Energy Commission, Nuclear Research Center "Demokritos" Aghia Paraskevi, Attica, Greece, August 1976.

SWEDEN

Reporting Format for Solar Heated Buildings with Comments: Summaries of Reports from three Swedish Solar Energy Buildings. Per Isakson and Egil Ofverholm, Royal Institute of Technology, Stockholm.

Reporting Format for Solar Energy Buildings, P. Isakson and E. Ofverholm, #D1:1977, Swedish Council for Building Research.

Solenergiprojekt I Sverige 1977 (Swedish Solar Energy Projects 1977), Engstrom et al, Swedish Council for Building Research.

Energy Conservation in Buildings R&D, Swedish Council for Building Research, #D1:1976.

Storage of Low Temperature Heat: Solar Energy Thermal Storage, G. Wettermark and J. Rowalewska, Swedish Council for Building Research, September 1976.

NE 1977:6, Results of NE-project 5562071 Solar Energy-Photochemical Conversion and Storage. Project results. Editors: Stig Claesson and Lars Engstrom. National Swedish Board for Energy Source Development.

Document D8:1977, The Termoroc House - an experimental low-energy house in Sweden, Bengt Rosengren, Swedish Council for Building Research.

SWEDEN Continued	Document D9:1977, Solar Energy House in Linkoping, Bertil Ahlstrom, Erik Hedman, and Bertil Dattermark. Swedish Council for Building Research.
THE NETHERLANDS	NOTE concerning energy conservation in dwellings, J. M. Van Heel, (Bouwcentrum, Rotterdam).
	Zonne-Energie voor Huisverwarming en Warm-Water-voorziening: Een onderzoekobject in de Afdelingen der Werktuigbouwkunde en Bouwkunde, Prof. Ir. C.W.J. Van Koppen. (Technische Hogeschool Eindhoven)
TURKEY	Solar Energy Utilization Related to the Heating and Cooling of Buildings in Turkey, Ministry of Energy and Natural Resources, 1976.
UNITED KINGDOM	An Appraisal of Solar Water Heating in the UK, R.G. Courtney, Building Research Establishment, #CP 7/76, January 1976.
	Solar Energy Utilization in the UK: Current Research and Future Prospects, R.G. Courtney, Building Research Establishment, #CP 64/76, October 1976.
	Solar Energy: A UK Assessment, International Solar Energy Society, UK Section, 1976.
UNITED STATES	National Program for Solar Heating and Cooling of Buildings, Project Data Summaries, Vol I: Commercial and Residential Demonstrations, Energy Research and Development Administration, Division of Solar Energy August 1976, ERDA 76-127.
	National Program for Solar Heating and Cooling of Buildings, Project Data Summaries, Vol. II: Demonstration Support, Energy Research and Development Administration, Division of Solar Energy, November, 1976, ERDA 76-128.
	National Program Plan for Solar Heating and Cooling of Buildings, Project Summaries, Vol. III: Research and Development, Energy Research and Development Administration, Division of Solar Energy, November 1976, ERDA 76-145.
	Interim Report: National Program Plan for Research and Development in Solar Heating and Cooling, Energy Research and Development Administration Division of Solar Energy, November 1976, ERDA 76-144.

UNITED STATES
Continued

Assessment of Solar Heating and Cooling Technology, J.D. Balcomb and J.E. Perry, Los Alamos Scientific Lab., LA-6379-MS, May 1977.

ERDA's Pacific Regional Solar Heating Handbook, Los Alamos Scientific Lab, November 1976.

Solar Heating Proof-of-Concept Experiment for a Public School Building. AAI Corporation. Timonium Elementary School, Timonium, Maryland, USA. NSF-RA-N-74-096. Government Printing Office Stock Number: 3800-00191.

Solar Energy School Heating Augmentation Experiment: Design, Construction, and Initial Operation. Inter-Technology Corporation. Faquier High School, Warrenton, Virginia, US. NSF-RA-N-74-019. Government Printing Office Stock Number: 038-000-00204.

Solar Energy Utilization for Heating and Cooling Compiled by John I. Yellot. Orginally published in the ASHRAE Guide and Data Book Series, Applications Volume, 1974. Government Printing Office Stock Number: 3800-00188.

Applications of Solar Heating and Cooling in Buildings prepared by the Building Research Advisory Board of the National Academy of Sciences.

Solar Heating Experiment on the Grover Cleveland School - General Electric Corporation - Grover Cleveland School, Boston, Mass. NSF-RA-N-74-064.
NTIS Accession No. PB 239 516.

Solar Heating and Cooling Experiment for a School in Atlanta - Westinghouse Electric Corporation - George A. Towns Elementary School, Atlanta, Georgia, Design Report. NSF-RA-N-74-122. NTIS Accession No. PB 240 611.

Design and Test Report for Transportable Solar Laboratory Program - Honeywell. NSF-RA-N-74-118B.
NTIS Accession No. PB 240 609.

Passive Solar Heating and Cooling Conference and Workshop Proceedings, May 18-19, 1976, Los Alamos Scientific Lab.

Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program, #NBSIR 76-1137, National Bureau of Standards, August 1976.

UNITED STATES
Continued

Solar Heating Proof-of-Concept Experiment for a Public School Building. Honeywell Inc., Systems and Research Center, NSF-RA-N-74-119.

Design, Construction, and Testing of a Residential Solar Heating and Cooling System. Solar Energy Applications Laboratory, Colorado State University, NSF/RANN/Se/GI-40457/PR/75/1, June 1975.

Development of Proposed Standards for Testing Solar Collectors and Thermal Storage Devices. National Bureau of Standards, NBS Technical Note 899, February 1976.

United States Special Format Report: Performance of the Sohio Solar Water Heating System Using Large Area Plastic Collectors, Lawrence Livermore Laboratory, May 1976, SAN/1038-76/1.

United States Special Format Report: Report of the Phoenix Corporation - City of Colorado Springs Solar Heating Project, Kaman Sciences Corporation, June 1976, WA/4578-76/1.

United States Special Format Report: Northview Junior High Solar Energy School Heating Augmentation Experiment, Honeywell Systems and Research Center, June 1976, COO/2624-77/1.

United States Special Format Report: Report of the George A. Towns Elementary School Solar Heating and Cooling Project Atlanta, Georgia, Westinghouse Electric Corporation Special Energy Systems, July 1976, COO/2628-76/1.

United States Special Format Report: Design, Construction and Testing of the Colorado State University Solar House I Heating and Cooling System, prepared by G.O.G. Lof and D.S. Ward, Solar Energy Applications Laboratory, Colorado State University, Fort Collins, Colorado, June 1976.

United States Special Format Report: Project Sage Solar Assisted Gas Energy Project, Southern California Gas Company, August 1976, SE/4691-76/1.

United States Special Format Report: Report on the Grover Cleveland School Solar Heating System, Boston, Massachusetts, General Electric Company, August 1976, COO/2626-76/1.

UNITED STATES
Continued

Interim Performance Criteria for Solar Heating and Cooling Systems in Commercial Buildings, #NBSIR 76-1187, National Bureau of Standards, November 1976.

Proceedings of the 1977 Flat-Plate Solar Collector Conference, February 28-March 2, 1977, Orlando, Florida.

Solar Energy Systems - Survey of Materials Performance, NBSIR 77-1314, National Bureau of Standards, October 1977.

National Program for Solar Heating and Cooling (Residential and Commercial Applications) Energy Research and Development Administration, Division of Solar Energy, October, 1975, ERDA-23A

Proceedings of the Workshop on Solar Energy Storage Subsystems for the Heating and Cooling of Buildings, Charlottesville, Virginia April 1975, Depts. of Chemical and Mechanical Engineering, University of Virginia, NSF-RA-N-75-041.

Proceedings of the Workshop on Solar Collectors for Heating and Cooling of Buildings, New York City, November 1974, Dept. of Mechanical Engineering, University of Maryland, May 1975, NSF-FA-N-75-019.

Catalog on Solar Energy Heating and Cooling Products, Energy Research and Development Administration, Division of Solar Energy, October 1975, ERDA-75.

Solar Energy: A Bibliography, Energy Research and Development Administration, March 1976, Vol. I, Citations: #TID-3351-R1P1; Vol. II, Indexes #TID-3351-RIP2.

Definition Report: National Solar Energy Research, Development, and Demonstration Program. ERDA, Division of Solar Energy, ERDA-49.

Method of Testing for Rating Thermal Storage Devices Based on Thermal Performance. Kelly and Hill, NBS, NBSIR 74-634.

Method of Testing for Rating Solar Collectors Based on Thermal Performance. Hill and Kusuda, NBS, NBSIR 74-635.

Solar Energy Heat Pump Systems for Heating and Cooling Buildings, Pennsylvania State University, COO-2560-1.

Description of the Solar Energy R & D Programs in Many Nations, F. deWinter, February 1976, SAN/1122/76-1.

UNITED STATES
Continued

Results and Analysis of a Round-Robin Test Program for Liquid-Heating Flat-Plate Solar Collectors. NBS975, National Bureau of Standards, August 1978.

Instrumentation Installation Guidelines. IBM Corporation, Solar/0001-77/15, November 1977.

National Program for Solar Heating and Cooling of Buildings. DOE/CS-0007, Department of Energy, July 1978.

Solar Heating and Cooling Research and Development Project Summaries. DOE/CS-0010, Department of Energy, May 1978.

APPENDIX F

PILOT STUDY PUBLICATIONS

Report on the Odeillo Solar Energy Experts Meeting, Presented at the CCMS Plenary, October 22-23, 1974, Brussels, Belgium, UMD-4908-1.

Report to the CCMS Spring Plenary, April 8-9, 1975, Brussels, Belgium, UMD-4908-2.

CCMS Solar Energy Pilot Study, F. Morse and I. Rose, Presented at the International Solar Energy Society Congress, July 28, 1975, Los Angeles, CA, UMD-4908-3.

Report to the CCMS Fall 1975 Plenary, October 14-15, 1975, Brussels, Belgium, UMD-4908-4.

Report of the Annual Meeting, August 4-6, 1975, Palo Alto, CA, UMD-4908-5.

Report to the CCMS Spring 1976 Plenary, April 27-28, 1976, Brussels, Belgium, UMD-4908-6.

Report to the CCMS Fall 1976 Plenary, October 11-12, 1976, Brussels, Belgium, UMD-4908-7.

Report to the CCMS Plenary, February 8-9, 1977,Dusseldorf, Federal Republic of Germany, UMD-4908-8.

Report of the Annual Meeting, September 13-15, 1976, Copenhagen, Denmark, UMD-4908-9.

Report to the CCMS Fall 1977 Plenary, October 18-19, 1977,Brussels, Belgium, UMD-4908-10.

Semi-Annual Progress Report, March 1978, UMD-4908-11.

Report of the 1978 Meeting, April 17-18, 1978, Dusseldorf, Germany, UMD-4908-12, CCMS Report #84.

Proceedings of the International Solar Conference on Performance of Solar Heating and Cooling Systems, April 19-20, 1978, Dusseldorf, Federal Republic of Germany, CCMS Report #85.

Report on the State of the Art in Solar-Assisted Low Energy Dwellings, CCMS Zero Energy House Group, October, 1978.

CCMS Solar Energy Pilot Study, Final Report, October 1978, CCMS Report #83 UMD-4908-13.